Likelihood for rubble-pile near-Earth asteroids to be 1st or Nth generation: focus on Bennu and Ryugu

*Kevin John Walsh[1], Ronald Ballouz[2], William F Bottke[1], Chrysa Avdellidou[3], Harold C Connolly Jr.[4], Marco Delbo[3], Daniella N DellaGiustina[2], Erica R Jawin[5], Timothy McCoy[5], Patrick Michel[3], Tomokatsu Morota[6], Michael C Nolan[2], Steven R Schwartz[2], Seiji Sugita[6], Dante S Lauretta[2]

1. Southwest Research Institute Boulder, 2. Lunar and Planetary Laboratory, University of Arizona, 3. Laboratoire Lagrange, Université Côte d'Azur, 4. Dept. of Geology, Rowan University, 5. Smithsonian Institution National Museum of Natural History, 6. University of Tokyo

Each asteroid collision and/or disruption event in the Main Belt produces an asteroid family consisting of a vast number of remnant objects. These families contain a distribution of sizes with many km-sized objects and fewer larger objects. All of these remnants themselves are subject to the collisional environment in the Main Belt, and many will be disrupted and destroyed, with some of the larger remnants being broken into smaller families of their own. Over time, the original family and all the subsequent generations of families drift around the Main Belt, and some small fraction of them find the dynamical pathways leading to orbits as near-Earth asteroids (NEAs). The smaller bodies, which drift faster and further, preferentially find the escape routes out of the Main Belt, which is reflected in the size of the population of NEAs. To best interpret the geology of km-sized NEAs currently being visited by space missions, we aim to determine how likely NEAs are to be 1st generation remnants from a disruption event in the Main Belt.

We created a model that tracked the survival of asteroid disruption remnants to understand the likelihood that they are direct rubble-pile products of a large asteroid family (1st generation) or the product of a slightly larger rubble pile that itself is the product of a larger asteroid family (2nd generation...up to Nth generation). The competition is between the very large numbers of the 1st generation km-sized family members racing against time to reach an escape route before being destroyed in a collision—versus 5- to 10-km rubble piles, moving much more slowly but more resistant to immediate destruction, being broken up eventually and having some of their remnants escape. We find that for scenarios in the inner Main Belt, the total number of escaping bodies is dominated by 1st generation rubble piles. For older families, those whose age is two or three times the collisional lifetime of the NEA of interest, the bodies reaching escape routes can be equal contributions of 1st and Nth generation rubble piles. Thus, the answer to whether a specific NEA is more likely a 1st or Nth generation rubble pile depends on knowledge of its parent family and that family's age.

Keywords: Near-Earth Asteroids, Rubble Pile Asteroids

