Itokawa, a >4.2 Ga old rubble pile asteroid

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Asteroid 25143 Itokawa is a rubble pile asteroid consisting of reaccumulated fragments from a catastrophically disrupted monolithic parent asteroid, and from which regolith dust particles have been recovered by the Hayabusa space probe. When and how did the collision that resulted in the initial breakup of Itokawa's parent body occur? In a previous study [1], we obtained an age of 2291 ± 139 Ma on a single particle (#0013) and combing this age with EBSD and diffusion modeling results, we concluded that asteroid Itokawa was already formed at 2.3 Ga thereby providing a minimum age for catastrophic asteroid breakup.

In this study, we present SEM, EBSD, ToF-SIMS, APT and $^{40}Ar/^{39}Ar$ dating results from four more particles (RA-QD02-0010, RA-QD02-0288, RB-CV-0082 and RB-QD04-1159). Unlike Particle #0013 [1], EBSD analyses show that none of these particles exhibit any noticeable sign of shock deformation, except perhaps one grain of troilite in particle #1159 which shows evidence of crystal-plastic deformation. Yet, $^{40}Ar/^{39}Ar$ analyses show the K/Ar system in all these particles has been reset at various ages with Particle #0288 and #1159 yielded two well-defined plateau ages of 4219 ± 35 Ma (P=0.58) and 4149 ± 41 Ma (P=0.27), respectively best interpreted as recording a high temperature, yet very low shock impact event.

Plagioclase-bearing equilibrated particles have recorded a series of impact events {~500 Ma, 1350 ± 250 Ma (multi-particles, [2]), 2291 ± 139 Ma [1], 4149 ± 41 Ma and 4219 ± 35 Ma} best interpreted as occurring at / or near the surface of Itokawa, which implies a larger version of the rubble pile was already formed by at least ~4.2 Ga. This suggests that rubble pile asteroids can survive ambient solar system bombardment for extremely long periods.

[1] Jourdan *et al.* (2017). *Geology* **45**, 819-822. [2] Park *et al.* (2015) *Met. & Planet. Sci.* **50**, 2087-2098.