Collisional history of asteroid Itokawa

F. JOURDAN[1], N. E TIMMS[2], E. EROGLU[1], C. MAYERS[1], A. FREW[1], P. A. BLAND[2], G. S. COLLINS[3], M. DAVISON[3], M. ABE[4] AND T. YADA[4]

[1]Western Australian Argon Isotope Facility, Curtin University, Australia. F.jourdan@curtin.edu.au.

[2]Department of Applied Geology, Curtin University, Australia.

[3]Department of Earth Science and Engineering, Imperial College, UK.

[4]Japan Aerospace Exploration Agency, Japan

In situ extraterrestrial samples returned for study (e.g., the Moon) are crucial in understanding the origin and evolution of the Solar System as, contrary to meteorites, they provide a known geological context for the samples and their analyses [1]. 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 [1].

We analysed two dust particles using Electron Backscatter Diffraction (EBSD) and $^{40}Ar/^{39}Ar$ dating techniques, the latter using an ARGUS VI mass spectrometer. One of the grains showing signs of 15-25 GPa impact shock pressure, yielded a $^{40}Ar/^{39}Ar$ plateau age of 2.3 ± 0.1 Ga. These data represents the first precise $^{40}Ar/^{39}Ar$ plateau age ever obtained from a single-grain dust particle recovered in situ from an extra-terrestrial body. Therefore, our approach opens a new era of single-grain analyses for precious, rare and small particles of extraterrestrial material.

Our diffusion and porosity-P-T models show that the relatively low pressure and high temperature involved in the impact process can be reconciled only if the asteroid was already made of porous material at ~2.3 Ga and thus, if asteroid Itokawa was already formed, thereby providing a minimum age for catastrophic asteroid breakup [1] [2]. A second particle shows no sign of deformation indicating shock pressure of < 10 GPa and a calculated maximum temperature of ~200°. This low temperature estimate is supported by an apparent $^{40}Ar/^{39}Ar$ age of 5.4 ± 1.6 Ga (i.e. an age of 3.8 - 4.6 Ga) indicating a lack of isotopic resetting for this particle. This suggests that the breakup of Itokawa's parent was a relatively low-temperature process and occurred on a pre-shattered parent body [3].

[1] Abe et al., *Science* (2006). [2] Tsuchiyama, *Elements* (2014). [3] Michel et al., Icarus (2004).