IMPACT HISTORY OF ITOKAWA: 40AR/39AR THERMOCHRONOLOGY AND EBSD CHARACTERIZATION.

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In situ extraterrestrial samples returned for study (e.g., the Moon, Itokawa) are crucial to understand the origin and evolution of the Solar System. One of the main goals of this study is to investigate the impact history of Itokawa using the $^{40}Ar/^{39}Ar$ and Electron Backscatter Diffraction (EBSD) techniques. We investigated two Pl+Py+Ol composite grains of 165µm and 91µm in diameter, provided by JAXA.

EBSD results: EBSD analyses show that the minerals appear as irregularly shaped and sized grains, with no crystallographic preferred orientations, common 120° triple junctions and negligible intra-grain lattice strain. None of the phases show obvious signs of shock. Absence of glass, high-pressure polymorphs, mosaicism, PDFs and crack damage seems to indicate that these particles did not experienced shock.

$^{40}Ar/^{39}Ar$ analyses: $^{40}Ar^*$ produced by the decay of ^{40}K is routinely measured by noble gas mass spectrometers. However, the tiny size of Itokawa's particles makes the measurements extremely challenging. Assuming an age of 1 Ga, the plagioclase from the biggest grain would produce 5.4×10^{-15} mol of $^{40}Ar^*$, equivalent to a total beam signal of only ~6 times the background level per step on a MAP 215-50 mass spectrometer. Although the Itokawa particles are now irradiated and ready to be analyzed, we decided to wait for the final commissioning of our new ARGUS VI mass spectrometer. Taking advantage of the small volume of the ARGUS VI and its sensitive ion counting detector will allow us to precisely measure very small ion beams (e.g., standards measured with the ARGUS VI yield a *ten-fold* increase in age precision).

Ar diffusion model: what to expect from these two grains? Direct observations of Itokawa's rubble-pile structure suggest that boulders on Itokawa are reassembled fragments formed by the catastrophic disruption of a significantly larger parent body (proto-Itokawa; e.g., [1]). Petrographic observations and new EBSD data show that the particles did not experience significant shock levels. For a non-porous body, this implies low temperatures, but for a 15% porous body, even low shock pressure can significantly increase the temperature [2].

In any case, the peak temperature associated with the disruption event was probably not sustained for a period of more than a few tenth of a second as (1) the particles would have cooled rapidly when exposed to the vacuum of space and (2) no melt component has been observed. Solid-state diffusion modeling and thermodynamic melting calculations predict that both a brief spike of temperature of *at least* ~6000°C and a cooling rate of 6000°C/s are required in order to reset the K/Ar clock of the plagioclase crystals without melting. However, it is not clear if these conditions would irreversibly change the crystallographic structure of the crystal aggregate at this scale, which is not observed.

Prospective: Ultimately, we plan to compare the new $^{40}Ar/^{39}Ar$ age data with the few $^{40}Ar/^{39}Ar$ ages measured on LL chondrites.

[1] Miyamoto et al., Sci. 2007; [2] Davidson et al., Icar. 2010.