RESULTS ON HAYABUSA SAMPLE ANALYSIS. A. Tsuchiyama[1], [1]Graduate School of Science, Osaka University, 1-1 Machikaneyama-cho, Toyonaka 560-0043, JAPAN, akira@ess.sci,oasaka-u.ac.jp (Present address: Graduate School of Science, Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto, 606-8052, JAPAN).

Introduction: It is accepted that most meteorites originate from asteroids, as demonstrated from orbital determination from observed meteorite falls. The materials on asteroids have been estimated by comparing reflectance spectra between asteroids and meteorites. Remote sensing observation by the Hayabusa spacecraft of JAXA [1] indicate that the materials on S-type asteroid Itokawa 25143 are similar to LL5 or LL6 chondrites suffered with space weathering.

Fine particles on Itokawa were successfully recovered from the smooth terrain by the Hayabusa mission [2-7]. They are not only the first samples recovered from an asteroid, but also the second extraterrestrial regolith to have been sampled, the first being the Moon. Itokawa samples allow a direct validation of the relation between asteroids and meteorites. In addition, the properties of Itokawa particles allow studies of regolith formation and evolution.

Preliminary examination (PE) of Hayabusa sample was carried out throughout 2011. This paper presents comprehensive results of PE.

Preliminary examination: About sixty particles (30-180 μm in size) were allocated for PE [2]. The total volume is ~4×10^6 μm^3 (~1.5 μg in mass), which corresponds to a sphere of ~200 μm in diameter [3].

University PE team (PI: A. Tsuchiyama) consists of seven sub-teams: (a) mineralogy and petrology [2,6] (sub-PI: T. Nakamura), (b) 3D structures [3] and surface microstructures [8] (A. Tsuchiyama), (c) elements [4] (M. Ebihara), (d) isotopes [5] and minor elements [9] (H.Yurimoto), (e) noble gas isotopes [7] (K. Nagao), (f) carbonaceous materials [10] (F. Kitajima), and (g) organic materials [11] (H.Naraoka). Specific grain-by-grain analyses for space weathering using HAADF-STEM [6] by sub-team (a) (4 particles), noble gas isotopes [7] by (e) (3 particles), and carbonaceous materials using micro-Raman and IR [10] by (f) and organic materials using HPLC and TOF-SIMS [11] by (g) (5 particles) were made separately to minimize contamination by terrestrial atmosphere and organic materials. Elemental analysis using NAA [4] by (c) (2 particles) was also made after extracting organic materials from the particles by (g). 48 particles (44 and 4 particles from the sample rooms-A and -B by spacecraft touchdowns-1 and -2, respectively) were analyzed grain-by-grain systematically in an analytical flow form non-destructive analyses using synchrotron facilities (x-ray tomography [3] by (b) and XRD and XRF [2] by (a)) to destructive analyses (FE-SEM, FE-EPMA and TEM [2] by (a) and SIMS [5,9] by (d)).

Results and discussion: We obtained the following results on Itokawa and its parent body throughout the solar system history: (1) formation of Itokawa parental body of >20 km in radius [2], which is composed of a LL chondrite material [2-5], (2) thermal metamorphism of the parent body <4.562 Ba [7] with the maximum temperature of ~800°C [2,3], (3) catastrophic impact and formation of Itokawa as a rubble pile asteroid by reaccumulation of impact fragments as already pointed out by [12], (4) regolith formation on Itokawa by impacts [3], (5) implantation of solar wind noble gases (grains appeared on the uppermost regolith layer for 100-1000 years) [7], (6) space weathering (formation of Fe-rich nanoparticles in thin surface layers (<~60 nm) of regolith particles [8], and (7) grain motion in the regolith layer [3] with the time scale of <~8 million years [7]. Any carbonaceous and organic materials have not been detected [10,11]

We concluded that the surface material of Itokawa is a mixture of LL4 to LL6 chondrites [2,3], which was suffered by space weathering [8], as expected from the Hayabusa remote sensing observation [1], and brought an end to the origin of meteorites. Active processes on the Itokawa surface and their chronologies were elucidated by examining the samples as regolith particles [3,6-8].

Many issues still remain to be solved for future studies; for examples, formation ages of the parent body and Itokawa, evidence of the catastrophic impact, founding of any exotic materials, such as organic materials, and comprehensive understanding of “space weathering” in a wide sense including Fe nanoparticle formation [6], implantation of solar wind and cosmic rays [7] and particle erosion [3,8].

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References: [1] Abe M. et al. (2006) *Science*, *312*, 1334-1338. [2] Nakamura, T. et al. (2011) *Science, 333*, 1113-1116. [3] Tsuchiyama, A. et al. (2011) *Science, 333*, 1125-1128. [4] Ebihara M. et al. (2011) *Science, 333*, 1119-1121. [5] Yurimoto H. et al. (2011) *Science, 333*, 1116-1119. [6] Noguchi T. et al. (2011) *Science, 333*, 1121-1125. [7] Nagao K. et al. (2011) *Science, 333*, 1128-1131. [8] Matsumoto T. et al. *LPS XLIII*, Abstract #1969. (2012) [9] Yurimoto H. et al. (2011) *Meteoritics & Planet. Sci., 46*, A260. [10] Kitajima F. et al. (2011) *LPS XLII*, Abstract #1855. [11] Naraoka H. et al. (2012) *Geochem. J*. in press. [12] Fujiwara A. et al. (2006) *Science*, *312*, 1330-1334.