SAMPLING STRATEGY AND CURATION PLAN OF "HAYABUSA" ASTEROID SAMPLE RETURN MISSION

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Introduction: On the 9th May 2003 JST, Japanese spacecraft "MUSES-C" was successfully launched from Uchinoura. The spacecraft was directly inserted to interplanetary trajectory and renamed as "Hayabusa", or "Falcon"to be the world's first sample return spacecraft to a near Earth asteroid (NEA) [1]. The NEA (25143)Itokawa (formerly known as "1998SF36") is its mission target. Its orbital and physical characteristics were well observed; the size is (490±100)x (250±55)x(180±50) m with about 12-hour rotation period [2]. It has a red-sloped S(IV)-type spectrum with strong 1- and 2-micron absorption bands, analogous to ordinary LL chondrites with space weathering effect [3]. Assuming its bulk density, the surface gravity level of Itokawa is in the order of 10 micro-G with its escape velocity = ~20 cm/s.

Mission Sequences: At present, the spacecraft is operated with three ion propulsion engine systems (IES) over 8,200 hour-units and cruising in a trajectory similar to the earth's orbit around the sun in order to make the swing-by in May 2004. Then it changes the course heading to the target NEA. In June 2005, the spacecraft will be inserted to the "home positioning" with Itokawa, which is nearly identical to the orbit of the asteroid itself. There the spacecraft will conduct global mapping with the multi-color optical camera, the near infrared spectrometer, the X-ray fluorescence spectrometer, and the LIDAR in the maximum duration of three months.

Sample Return Strategy: After completing global mapping, the first descent for "touch-and-go" sampling will be conducted. Before touching to the surface, one of three "target markers" will be dropped and tracked its passage by autonomous navigation. Also a hopping rover "MINERVA" will be deployed..

However it is still not possible to fully understand surface conditions of such minor bodies only from ground observation. Thus HAYABUSA employs a sampling mechanism that suits for a diverse heterogeneity of target surfaces, from metal-silicate hard surfaces to regolith layers covered with fluffy microparticles [4]. It carries a 1-m horn made from (1) Al metal cylinder horn at the tip, (2) foldable, compliant fabric horn (Vectoran) and (3) Al metal conical horn connected to the sample catcher inside. The sampling mechanism is attached to the basement of the spacecraft and consists of (a) a sample catcher canister coated with 99.9999% Al, (b) a transfer mechanism to the re-entry capsule, and (c) projectors whose gun powder cartridges conceal residual gas inside. Within 0.3 seconds after the tip of the horn touches on the asteroid surface and the laser range finder detects deformation of the fabric horn in >1cm. Simultaneously, a Ta projectile of 5-g mass is shot at velocity 300 m/sec by a small projector onto the asteroidal surface. Impact of the projectile produces surface ejecta, which are concentrated through the conical horn toward the catcher. The catcher is finally transferred into the re-entry capsule and tightly sealed.

In order to evaluate behavior of impact ejecta from small asteroids, we performed both 1G and reduced gravity impact experiments (>10^{-5}G) onto various asteroid surface analog materials such as porous, heat resistant bricks, 200-miron sized glass beads and lunar regolith simulant [5]. As the results, the expected amount of the samples from results of 1G and microgravity impact tests for both consolidated bed rocks and regolith simulants are around several hundred mg to several g per shot (Fig.2). The majority of recovered samples were fine-grained (sub-mm size) particles, rather than large chips (>several mm) of rocks. Yet a few grams of powder sample collection are considered as a great success, thanks to current advancement of micro-analytical technology.

The sampling will be repeated up to three locations before leaving the asteroid in November 2005. In June 2007, the return capsule will be released for the earth re-entry and land on Woomera, Australia.

Fig.1. HAYABUSA descending to the asteroid surface for sampling (CG: A. Ikeshita/ MEF /ISAS)

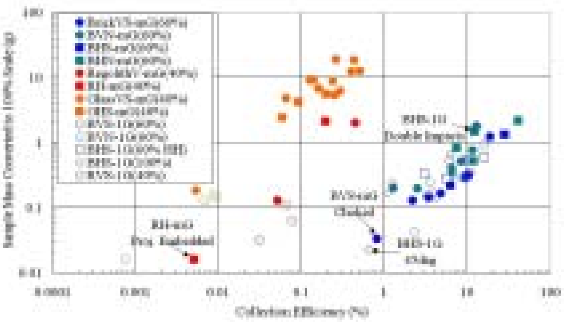

Fig. 2. HAYABUSA sampler collection efficiency and collected mass in 1G and Micro-G. Symbols: B = brick, R = regolith, G = glass beads, H = horizontal horn, V = vertical horn, S = with shoulder of the funnel, N = without shoulder, mG = micro-G.

Sample Analyses: In order to maximize scientific output from recovered samples in 2007, the samples should be distributed to all qualified researchers upon proposals from all over the world. Such detailed analysis proposals must rely on general characteristics of the samples studied by the initial analysis team, the "MUSES-C Asteroidal Sample Preliminary Examination Team (MASPET)". Thus it is also important for JAXA/ISAS to create its own astromaterial curation facility on site.

The initial analysis will investigate physical properties (e.g., mass, size distribution, morphology, color, transparency, etc.) and produce optical calibration data for the on-board instruments from 100 mass % of bulk samples by non-destructive means [6]. Then up to 15 mass % will be consumed to characterize the representatives of Itokawa samples for more details and publish their results within one year after the capsule retrieval. Given a sufficient amount of the samples (i.e., >several 100 mg) is recovered, after the initial analysis period the international announcement of opportunity (AO) for detailed analyses of another 15 mass % of the samples will be released. The other 15 mass % will be used for competitive AO only open to Japanese scientists while the other 10 mass % will be permanently transferred to NASA. The rest will be preserved for future use.

MASPET Competition: MASPET will consist of ISAS scientists, NASA and Australian Co-Is, and Japanese researchers from outsourcing institutions, who are selected through the open competitions of mostly non-destructive, microanalysis techniques in respective disciplines needed during the initial analysis stage. They will work as one "all-Japan" team and are responsible for characterizing the general features of the bulk and some of major samples.

The first competition was conducted in 2000-2001 and the HAYABUSA Sample Advisory Committee endorsed the final recommendation in May 2002 [6]. A total of eleven applications from a variety of analytical disciplines were received and peer-reviewed. The applications included (but not restricted to) the following techniques: (1) selected isotopic measurements, (2) ion probe (including SHRIMP), (3) carbonates, (4) organics & carbon isotopes, (5) major & trace elements, (6) micro-tomography, (7) mineralogy & petrology, (8) noble gas, (9) nuclear activation, and (10) residual magnetism [7]. Nine of them received two sets of unknown test samples to demonstrate their self-claimed analytical performance. These "unknown" samples were the UNSM3529 fraction of Allende (CV3) [8] and Valdinizza (L6) [9]. Multiple international referees evaluated their reports and six of them were recognized as qualified to join the MASPET as of 2002. Yet analytical instruments, techniques, and personnel may advance greatly in next several years, before the 2007 sample retrieval. Therefore, while the recognition of qualification through the first competition significantly counts, we shall repeat this competition once more (planned to announce in 2004) in order to invite the best experts in the whole analytical techniques at the time of the sample return. The final membership of the MASPET should be decided in the late 2005, right after the spacecraft leaves the asteroid.

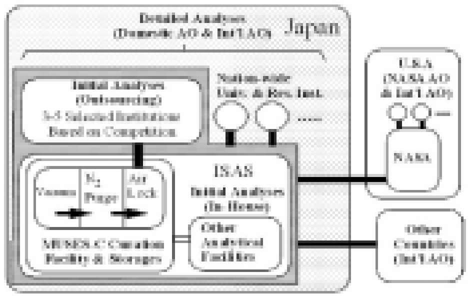

Fig. 3. HAYABUSA sample analysis flow

References: [1] J. Kawaguchi, et al. (2000) *Prof. 22nd ISTS*, 2000-o-3-06v. [2] M. Kaasalainen, et al. (2002) *Proc. ACM 2002*, ESA SP-500. [3] R.P. Binzel, et al. (2001) *Meteoritics & Planet. Sci.*, 36. [4] J. Veverka, et al. (2001) *Science*, Vol. 292, 484-488. [5] H. Yano,et al. (2002) *Proc. ACM 2002*, ESA SP-500. [6] H. Yano, et al. (2003) ISAS SP -16,1-8, [7] I. Kushiro, A. Fujiwara and H. Yano (eds.) (2003) *The First Open Competiton for MASPET*, ISAS SP-16, 159pp. [8] E. Jarosewich, et al. (1987) *The Allende Meteorite Reference Sample*, Smithsonian Institution. [9] G.R. Levi-Donati and E. Jarosewich (1971) *Meteoritics*, 6, No.1, 1-14.