MICROGRAVITY GEOLOGY: A NEW CHALLENGE FOR SOLAR SYSTEM SMALL BODY EXPLORATION. H. Yano[1,2] [1]JAXA/ISAS (3-1-1 Yoshinodai, Chuo-ku, Sagamihara, Kanagawa 252-5210, JAPAN, e-mail: yano.hajime@jaxa.jp), [2] JAXA/JSPEC.

Introduction: The current theory of planetary system formation still pauses several "black boxes" such as the intermediate state between dust-to-dust aggregation and planetesimal growth/ disruption that are never able to be studied from exploration of large, differentiated bodies. Yet, no one had witnessed geological evolution of small planetesimals or equivalent, until Hayabusa's in-depth exploration of Itokawa, a sub-km rubble pile asteroid. Geological features of Itokawa surprised scientists about both similarities and differences from larger asteroids like Eros and much larger satellites/planets.

Needs of Microgravity Geology: Apparent similarities between Itokawa and the Earth (and Mars) are not necessarily due to the same geological processes as the terrestrial geology are largely affected by the presence of water in atmosphere, surface and underground, let alone five orders of magnitude difference of G-levels (Fig. 1, 2) [1]. There has been a need to create a new research field of "Microgravity Geology" in order to better understand missing links or these black boxes of the planetary evolution processes, as well as better preparation for future robotic and human explorations to such microgravity bodies [2]. Such knowledge can also be beneficial to natural disaster management on the Earth for better understanding of their triggering mechanisms.

Key Physical Processes: Understanding physical processes in microgravity geology include: (1) impacts (e.g., gravity-strength regime scaling, ejecta redistribution, low density/weak strength monolithic targets vs. granular targets, etc.), (2) vibration (e.g., wave propagation, seismic efficiency, diffusivity, quality factor, etc. in regolith and low density targets), and (3) granular Mobility (Brazil Nuts effect, granular convection, electrostatic dust levitation, surface mobility, non-gravitational activities such as cometary gas release, etc.). Also investigation of effects by other internal/external forces than impacts such as centrifugal force, YORP, and tides is crucial (Fig. 3).

Small Body Exploration Development: As for application to the Solar System small body exploration, numerical simulations and laboratory experiments in microgravity to reduced gravity conditions are necessary to develop scientific and engineering instruments as well as total and sub-systems of spacecraft, landers and rovers for exploring such bodies. To name a few, the sampling device, the target markers, the micro-rover onboard the Hayabusa spacecraft were all developed by conducting microgravity experiments in drop towers and parabolic flights. The Hayabusa follow-on mission (e.g., Hayabusa-2) also utilizes these experimental facilities for further advancing these sub-systems and new instruments to be separated from the mothership.

Experimental Facilities: Thus, due to both scientific and engineering motivations, the small body exploration is a relatively new but definitely growing field of microgravity research. For successful pursue of these scientific quests and engineering requirements, appropriate selection and co-ordination of microgravity experiment facilities, both unmanned and man-tended means, are vital; current options of such facilities in international levels include one-way drop tower, catapult drop tower, high altitude balloon, parabolic flights, sounding rocket, sub-orbital flights, free flyer satellites, and LEO space stations.

References: [1] Yano, H. (2009) International Marco Polo Symposium and other Small Body Sample Return Missions, University of Paris, Paris, France. [2] Yano, H. (2010) Workshop on Numerical Modeling of Asteroids as Granular Systems, January 2010, Château, CIAS/Observatorie de Paris, Paris, France.

Fig.1: Diverse geology on surfaces of the Earth

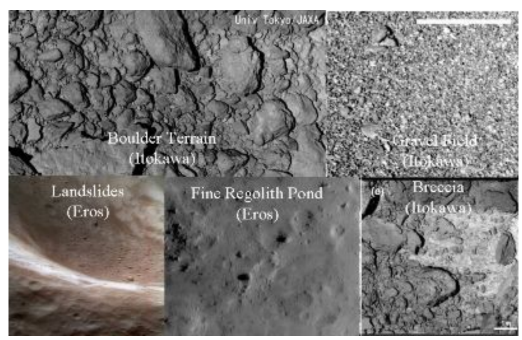

Fig.2: Similar geology on microgravity surfaces of asteroids

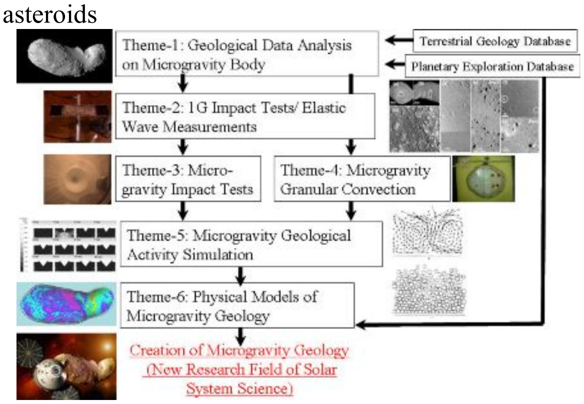

Fig.1: Study flow example of microgravity geology