Geology on small airless bodies

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Space missions are headed off to collect and return samples from the surfaces of asteroids. The most accessible asteroids are km-sized near-Earth asteroids, which consist of short-lived (~10Myr) visitors to the inner Solar System whose current orbits do not reveal where they, or their parent bodies, formed. However, basic physical properties, their shapes and spins, suggest dramatic physical evolution and our meteorite collections provide insight into the geologic evolution of a plethora of possible parent bodies. Returned samples can link asteroids with specific meteorite classes and advance the study of surface geology and recent physical evolution.

The Hayabusa mission to Itokawa found a highly elongated body covered alternately in smooth ponds of small grains or very large blocks and boulders. The images and surface geology of Itokawa did justice to the moniker "Rubble Pile", and generally showed signs of significant transport of surface materials. Analysis of the returned sample allowed positive links with known meteorite classes [1], validation of suspected space-weathering processes [2] and also indications of epochs of re-surfacing [3].

Meanwhile JAXA's Hayabusa2 mission and NASA's OSIRIS-REx mission both seek to return samples from low-albedo primitive targets, Ryugu and Bennu respectively. Unlike Itokawa, they are not elongated [4,5], and Bennu has a "top-shape" that is found among a large fraction of rapidly rotating small asteroids. This is typically attributed to re-shaping during phases of spin-rate increases [6]. The implications for surface geology are vast – including latitudinal variations in properties that has already been suggested from thermal and spectral data [7]. As with Itokawa, samples returned from the surface will constrain recent surface evolution while also providing links to specific meteorite classes and parent body evolution in the Main Belt.

References: [1] Nakamura et al. (2011) *Science* **333**, 1113 [2] Noguchi et al. (2011) *Science* **333**, 1121 [3] Nagao et al. (2011) *Science* **333**, 1128. [4] Tachibana et al., 2014 *Geochem. J.* **48,** 571 [5] Lauretta et al. (2014) *Meteoritics and Planetary Science* **50**, 834 [6] Walsh et al. (2008) *Nature* **454**, 188. [7] Binzel et al. (2015) *Icarus* **256**, 22.