**MERCURY HOLLOWS: A POSSIBLE ANALOG FOR PHAETHON.** David T. Blewett[1]. [1]Planetary Exploration Group, Johns Hopkins University Applied Physics Laboratory, Laurel, Md., USA. (david.blewett@jhuapl.edu).

**Introduction:** Asteroid (3200) Phaethon is an object of the B spectral class, ~5 km in diameter. Phaethon is remarkable because of its small perihelion distance (0.14 astronomical units, AU), because it has a dynamical association with the Geminid meteor stream [1], and because it has been observed to undergo anomalous perihelion brightening [2, 3] and development of a dust tail [4]. Phaethon is the target of a flyby mission, *DESTINY*, to be undertaken by the Japanese space agency (ISIS/JAXA) [5].

Because of its close approach to the Sun, Phaethon experiences equilibrium surface temperatures at the sub-solar point that exceed 1000 K (727 °C) [6]. The generation and ejection of dust on this "rock comet" is attributed to thermal stresses and/or dehydration of the constituent hydrated minerals [6]. Solar radiation pressure likely sweeps out the small particles (~1 μm diameter) into the observed dust tail. Observations of other small near-Sun asteroids (NSAs, with perihelion distances <0.24 AU) found no evidence for mass loss [7].

Mercury, the innermost planet, orbits the Sun with a perihelion distance of 0.31 AU. Temperatures on Mercury's equator can approach 700 K (423 °C) [8]. Geochemical sensing by the *MESSENGER* spacecraft reveals that the surface has a higher abundance of volatile and moderately volatile elements (sodium, chlorine, sulfur, and potassium) than had been expected [9-12], and that carbon in the form of graphite is an important constituent of the crust [13, 14]. Mercury is home to a class of unusual shallow depressions, called hollows (Fig. 1) [15-18]. Hollows have a fresh appearance and lack superposed small impact craters (Fig. 1c), indicating that they are among the youngest non-impact features on the planet and may be actively forming in the present day. Formation of hollows appears to involve sublimation-like loss of a volatile phase, crumbling of the de-volatilized matrix, and enlargement of the depressions by scarp retreat [17]. Fracturing by thermal stresses [e.g., 19] could contribute to exposure of fresh material. Candidate minerals that may be lost include sulfides; space-weathering-related depletion of iron sulfide has been proposed to take place on near-Earth asteroid Eros [20, 21]. Alternatively, solar-wind proton bombardment of mercurian graphite (carbon) could lead to formation and loss of methane [17]. Hollows are often surrounded by high-reflectance haloes; photometric evidence for the presence relatively fine-grained material in the haloes [22] suggests that dust may be generated in the hollow-forming process. Under Mercury's high surface gravitational field, dust lofting by gas lift during volatile loss is not likely to have been responsible for formation of the bright haloes. Other potential means for dispersal of dust [17] include energetic thermal decomposition of volatiles, build-up and explosive release of gas pressure (perhaps methane), or electrostatic dust levitation.

**Loss of Material from Phaethon:** Carbonaceous chondrite (CCs) meteorites are considered to be analogs for B-type asteroids, with CI chondrites providing a close spectral match [e.g., 23]. Experimental heating of CCs [e.g., 24-27] to temperatures relevant to Phaethon's perihelion conditions demonstrates that dehydration of phyllosilicate minerals leads to structural changes in the minerals and initiation of shrinkage cracks. Heating-induced changes to reflectance characteristics include decreases in the strength of phyllosilicate absorption features in the ultraviolet, near 0.7 μm, and near 3 μm [25, 25]. Dehydration of phyllosilicates and degradation of organic components in CCs [28] might lead to loss of material and formation of topographic depressions analogous to mercurian hollows.

It was estimated [29] that Phaethon lost a mass ($m$) of $10^4$–$10^5$ kg of material in the form of small (~1 μm) particles during the 2016 perihelion passage, similar to estimates from the 2009 and 2012 perihelia [4]. The Geminid stream is comprised of larger particles, so the total mass loss is likely to be greater [30]. The average bulk density (ρ) of CI meteorites is 2110 kg/m$^3$ [31]. From this, we can estimate the volume, $V$, of material lost: $V = (m/\rho) = \sim 5–50\ \mathrm{m}^3$. This loss might take place uniformly across the surface of the asteroid. Or, mass loss could be concentrated in particular locations, in the manner of cometary jets or the loss of material from mercurian hollows. A circular depression 10 cm deep and ~8–25 m in diameter encompasses the volume range estimate.

**Discussion/Conclusions**: Phaethon experiences a space-weathering environment unlike that of other objects that have been visited by spacecraft, although Mercury - with a high flux of high-speed micrometeoroids [32, 33], high solar-wind flux, and high temperatures - is the most similar. Phaethon may have space weathering outcomes that differ from those of Main Belt or near-Earth C-complex asteroids. Observations by *DESTINY* may reveal the presence of unusual landforms produced by extreme space weathering.

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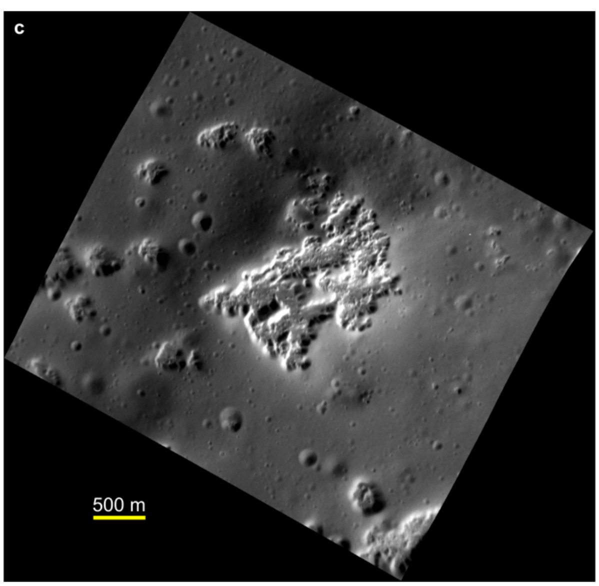


**Fig. 1c.** Targeted image (3.8 m/pixel) is a close-up of the cluster of hollows indicated by the arrows in Figs. 1a and 1b. [17]

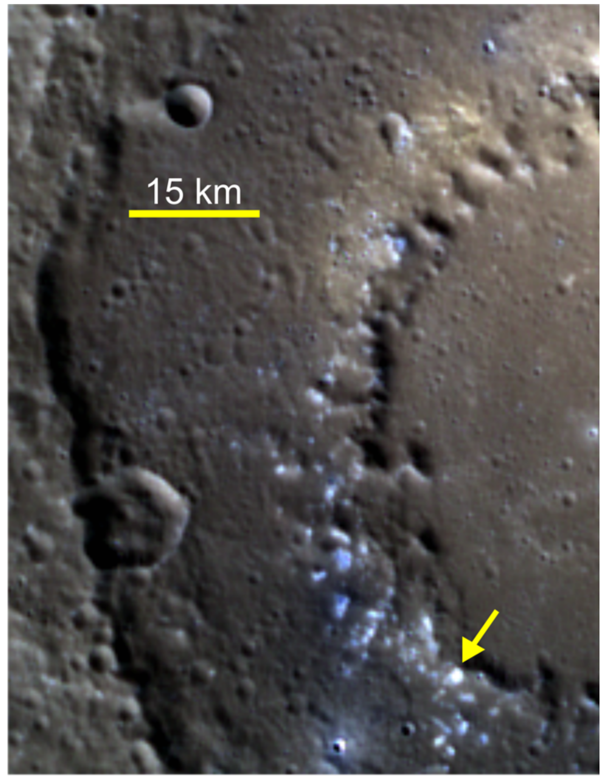


**Fig. 1a.** *MESSENGER* color-composite image of western Scarlatti basin, Mercury. Hollows are the high-reflectance, bluish spots on and around the inner basin ring. Yellow arrow: hollows shown at higher resolution in Figs. 1b and 1c. [17]

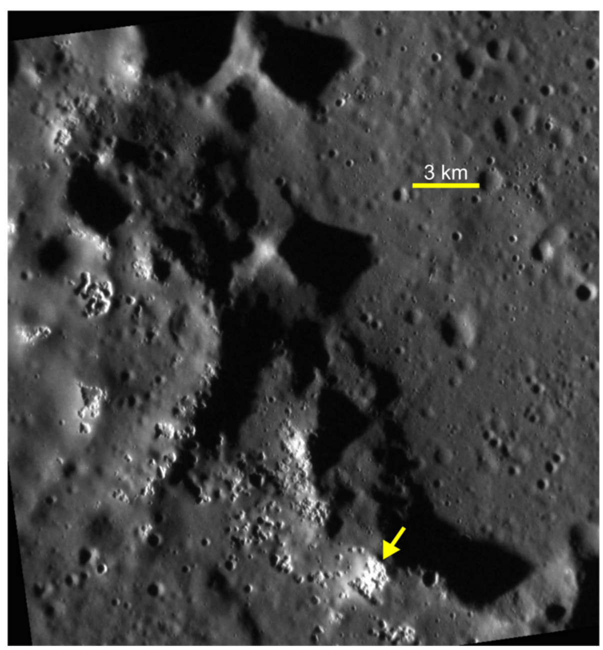


**Fig. 1b.** Scarlatti's southwestern inner ring (30 m/pixel). The arrow points to the cluster of hollows indicated in Fig. 1a and shown at higher resolution in Fig. 1c. [17]