LONG-LIVED, VOLATILE-DRIVEN MODIFICATION OF CALORIS EJECTA BLOCKS. J. Wright[1], S. J. Conway[2], D. A. Rothery[1] and M. R. Balme[1], [1]School of Physical Sciences, The Open University, Milton Keynes, MK7 6AA, UK (jack.wright@open.ac.uk), [2]CNRS UMR 6112, Laboratoire de Planétologie et Géodynamique, Université de Nantes, France.

Introduction: Numerous, kilometer-scale, conical knobs are associated with the Caloris basin [1]. The current favored explanation for these knobs is that they are Caloris ejecta blocks [2], although a volcanic origin has also been suggested [3]. If these landforms are ejecta, then they provide an opportunity to investigate material excavated from Mercury's lower crust/upper mantle [4]. However, it remains unclear why such ejecta blocks should be conical. We have mapped the spatial distribution of the circum-Caloris knobs, made detailed photogeologic observations of them, and measured their flank slopes to investigate their formation and evolution.

Data and Methods: Knobs were mapped up to 1500 km from Caloris at all azimuths using the ~166 m/pixel MESSENGER global monochrome mosaic [5].

We made photogeologic observations of high resolution Mercury Dual Imaging System (MDIS) [6] data.

Topographic profiles for slope measurement were made using Mercury Laser Altimeter (MLA) [7] tracks. Most knobs lacked MLA data, so we used shadow measurements [8] to make further topographic profiles.

Results: Our catalogue contains 2017 knobs. It is complete for knobs ≥5 km in diameter (n = 545).

Knob distribution. (Fig. 1) Knobs are densely spaced proximal to Caloris' rim and sparser farther from the basin. Knobs within Caloris are <100 km from the rim. The most distal knobs occur ~1000 km outside the rim. Knobs are occasionally arranged in chains radiating from the center of Caloris. Knobs are characteristic of the Odin Formation but also occur abundantly on the locally elevated positions (crater rims, lobate scarps). Lower-lying circum-Caloris regions are typically smooth plains with fewer, more isolated knobs. These observations are consistent with the Odin Formation being a knobby ejecta facies that has been partially buried by later, volcanic smooth plains.

MDIS observations. Knobs are typically featureless cones or domes. Clustered knobs form multi-knob landforms that impinge upon each other's bases. Narrow-angle camera (NAC) frames (tens of meter resolution) show these knobs are substantially less cratered than the plains. Contacts within the Odin Formation are diffuse, whereas smooth plains contacts are sharper. Knobs appear to have a weak blue color anomaly.

38 knobs partially obscure impact craters on the surrounding plains, demonstrating post-formation modification (Fig. 2). 10 knobs have hollows (Fig. 3a), which suggests knobs contain volatile materials [9].

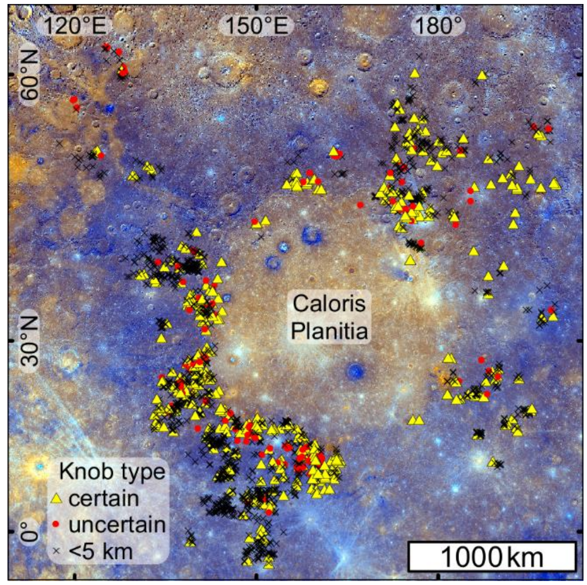

Fig. 1. *All knobs ≥5 km across are shown.*

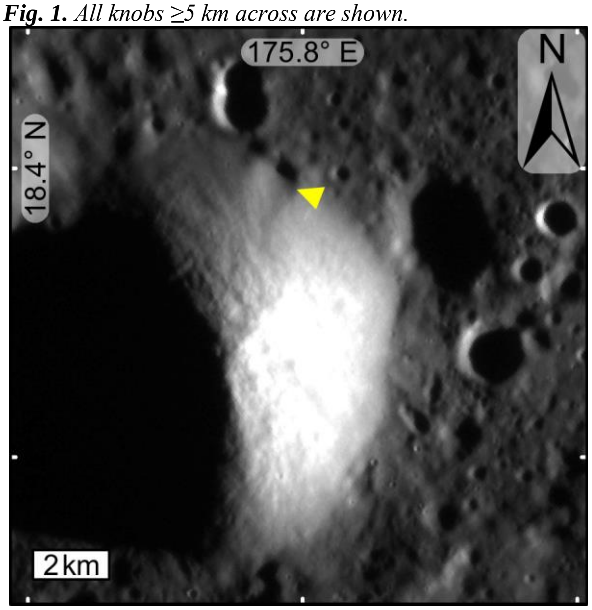

Fig. 2. *Conical knob. Yellow arrow indicates crater on Caloris Planitia partially obscured by knob material. A subtle notch in the knob is visible above this crater.*

Knob topography. Of the 545 knobs ≥5 km across, only 22 have useful MLA tracks. Pristine knobs have planar flanks, but degraded knobs are generally convex-up. Median slopes of ~20° were typically measured.

134 knobs ≥5 km in diameter have shadows suitably cast for shadow-length calculations [10]. Of these, 15 have MLA data for comparison. These comparisons show that the shadow technique we have modified from

[8] adequately reproduces knob flank slopes (Fig. 3). The median slopes calculated from shadow-derived topography are also ~20°. Many knobs are characterized by steeper slopes, but importantly these approach (but do not exceed) 32°, which is the angle of repose of unconsolidated material on Mercury [10].

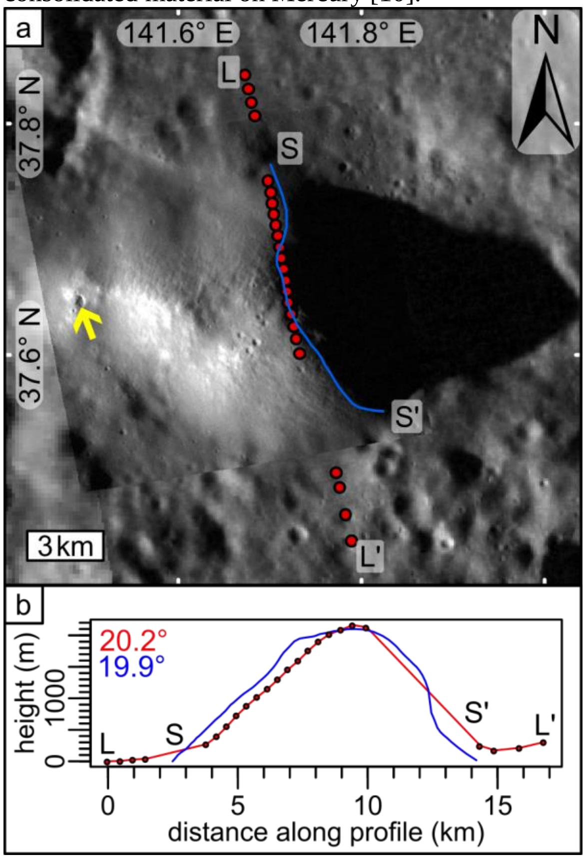

Fig. 3. *(a) A knob with MLA data (red profile L–L') and shadow data (blue profile S–S'). Yellow arrow indicates hollow in knob. (b) MLA- and shadow-derived topographic profiles and flank slopes shown in red and blue, respectively.*

Volatile-driven knob modification: We suggest that the circum-Caloris knobs are Caloris ejecta blocks that have been modified into cones over geological time. Few processes expected to operate on an airless body might form cones from arbitrarily shaped blocks. For example, impact gardening is a diffusive process that tends to subdue topographic contrasts by rounding them off [11]. This is incompatible with our observations of steep sided, conical knobs. To 'sharpen' a block into a cone, an advective mass transport mechanism that transports material exclusively downslope is required. This process would need to be faster than impact gardening and long-lived for conical knobs to be observable today.

Hollows appear to form by the loss of a volatile crustal component to space causing a depression to open [9]. Freshly exposed volatiles are subsequently lost and the hollow expands by scarp retreat. This is an advective process that forms sharp-edged, steep-walled hollows. We suggest that the circum-Caloris knobs formed by scarp retreat of Caloris ejecta blocks due to the loss of a structurally integral volatile component, evidenced to be present in some knobs due to them hosting hollows. Devolatilization causes disintegration of the block. Inert material cascades off the block and exposes fresh volatile material (Fig. 4). This is similar to how 'molards' on Earth form [12]. This explains how knob material has encroached on craters and scarps that postdate Caloris.

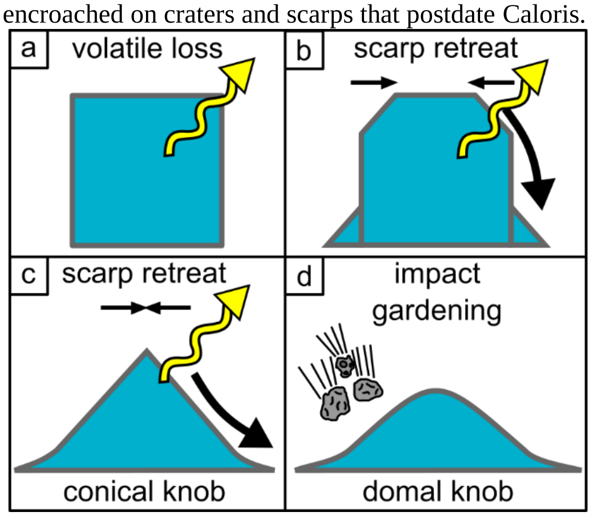

Fig. 4. *(a) Following emplacement, a structurally integral volatile is lost (yellow arrow). (b) Disintegrated material gathers at the bottom of the block (large black arrow). A fresh face is exposed. (c) Continued scarp retreat produces a conical knob. (d) When devolatilization becomes slower than impact gardening, a conical knob is modified into a dome.*

Implications: The circum-Caloris knobs were excavated from depth [2]. If their evolution was volatile-driven, then these knobs provide evidence that Mercury's deep interior is as volatile-rich as its surface.

This mechanism is not predicted to have been active on the Moon, due to its volatile-poor composition. Our preliminary study of Imbrium ejecta blocks in the Alpes Formation suggests that lunar knobs are not as steep as the circum-Caloris knobs, which suggests no long-lived angle of repose processes have acted on them.

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