SOURCE OF MERCURY'S HOLLOW-FORMING MATERIALS: PRELIMINARY INSIGHTS FROM IMPACT SIMULATIONS AND MASCS SPECTRA. J. Wright[1], E. Caminiti[2], A. S. P. Rae[3], and S. Besse[1], [1]European Space Agency (ESA), European Space Astronomy Centre (ESAC), Camino Bajo del Castillo s/n, 28692 Villanueva de la Cañada, Madrid, Spain (jack.wright@esa.int), [2]LESIA, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Université de Paris, 5 place Jules Janssen, 92195 Meudon, France. [3]Department of Earth Sciences, University of Cambridge, Cambridge, CB2 3EQ, UK

Introduction: Historically, Mercury's large core [1] has been explained by energetic processes, such as giant impacts [2,3], or differential accretion [4,5] or volatilization [6] of its silicates because of its innermost position within the Solar System. However, MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) data indicate Mercury's surface is enriched in volatile elements [7], which would be preferentially lost if subjected to such energetic processes. Hollow formation is one putative volatile-driven surface process on Mercury [8]. If the hollow-forming materials are only shallowly sourced, then perhaps they were delivered in a late accretionary phase after any energetic processes [2–5] that left the core relatively enlarged. Deeply sourced hollow-forming materials would require energetic processes to have occurred sufficiently early in Mercury's history to allow for re-accretion of volatile species and their redistribution Mercury's silicate portion. However, direct evidence of how deep in Mercury's subsurface the hollow-forming volatile materials are is lacking.

The Caloris basin is the largest well-preserved impact basin on Mercury [9], and so has excavated material from great depths within Mercury. The "circum-Caloris knobs", ostensible Caloris ejecta block remnants, have been suggested to have been shaped by volatile-loss-driven mass wasting [10], and the presence of observable hollows in some knobs suggests that hollow-forming materials might be the volatiles involved. Here, we use iSALE numerical impact simulations [11 and refs therein] to constrain the depth of excavation of these knobs, to place a bound on the thickness of Mercury's silicate portion that contains hollow-forming materials. We use data from MESSENGER's Mercury Atmospheric and Surface Composition Spectrometer (MASCS) [12] to see if these knobs have characteristic spectra, and if so, how they compare with hollows [13] and other terranes, including the Odin Formation that hosts them. It is important to search for non-geomorphic (e.g., spectral) evidence of hollow-forming materials in the circum-Caloris knobs as much of the geomorphic evidence might have been destroyed by slope processes.

Methods: Expanding on the work of [10], we are making a geological map of the Odin Formation, the putative host of the circum-Caloris knobs. We are using iSALE numerical impact simulations to estimate the subsurface source of the knobs and Odin Formation based on where they occur in our geological map. We are using MASCS spectra to constrain the composition of the knobs and Odin Formation, paying particular attention for the spectral signature of hollows [13].

Geological mapping. We are using the 166 m/pixel global Mercury Dual Imaging System (MDIS) [14] monochrome basemaps and individual higher-resolution MDIS images with varying illumination conditions, which are helpful for distinguishing the subtle, knobby texture of the Odin Formation from the surrounding plains. We are mapping at a scale of 1:300,000. The maps of the Odin Formation, the circum-Caloris knobs [10], and the hollows they host are context for the impact simulation and MASCS spectra studies.

Impact simulations. Here, we have rerun the simulations of [15] capable of reproducing the Caloris basin with some updated parameters (Table 1).

Table 1. Selected Caloris basin-forming impact parameters.

Parameter	Best value	Low value	High value
Impactor velocity	42 km/s	25 km/s	50 km/s
Impactor diameter	100 km	80 km	140 km
Impactor density	3300 kg/m^3 (dunite)	—	—
Planetary radius	2439.4 km	—	—
Crustal thickness	35 km	23 km	50 km
Crustal density	2900 kg/m^3 (basalt)	—	—
Mantle density	3300 kg/m^3 (dunite)	—	—
Core radius	2024 km	—	—
Surface gravity	3.7 m/s^2	—	—
Subsurface thermal gradient	—	8 K/km	15 K/km

MASCS spectra. We are searching the Mercury Surface Spectroscopy (MeSS) database [16] for MASCS spectra of circum-Caloris knobs and the Odin Formation. The steep slopes of the knobs make spectral interpretations challenging, so we will select spectra with great care.

Results: We have run eight Caloris basin-forming impacts so far and begun our spectral analysis of the circum-Caloris knobs and Odin Formation.

Impact simulations. A representative model is shown in Figure 1. Most material that could have been deposited as the Odin Formation is sourced from Mercury's crust (< 35 km depth) and remained solid throughout the impact.

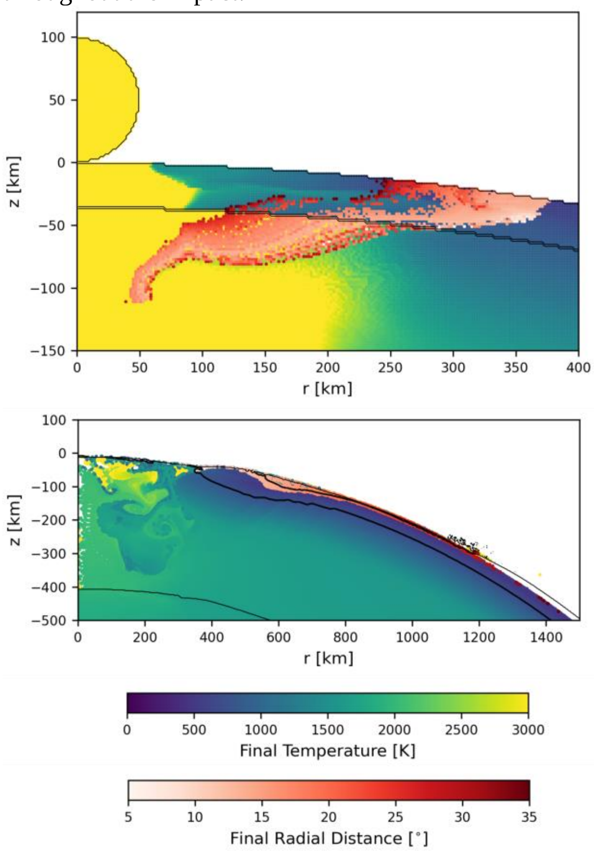

Figure 1. Upper panel: 100 km-diameter impactor and pre-impact topography. Lower panel: post impact topography. Cells in both panels are color-coded by their final calculated temperature. Both panels show red cells that trace materials excavated by the impact and deposited at or near the surface.

MASCS spectra. Our preliminary analysis shows variability with circum-Caloris knob spectra, including some knobs with similar spectral properties to hollows (Figure 2, knob5 and knob6).

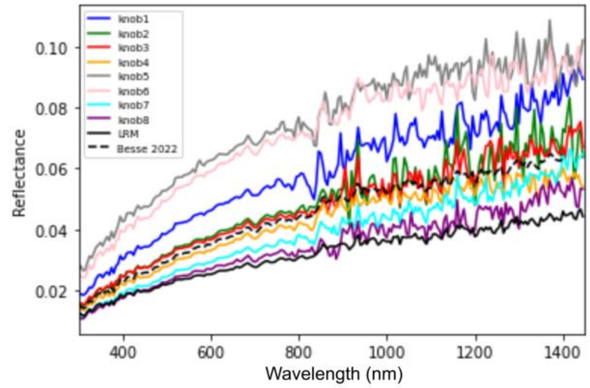

Figure 2. Example circum-Caloris knob reflectance spectra.

Discussion and Future Work: Our impact simulations suggest that solid ejecta, capable of preserving hollow-forming materials, is sourced from the whole thickness of the crust, but not necessarily any deeper. We will finish mapping the Odin Formation and circum-Caloris knobs, noting the hollows they contain. We will analyze carefully selected MASCS spectra of the circum-Caloris knobs to test if they have similar spectral properties to hollows [13] even where none is observable. We will use the locations of the hollow-like spectra to refine our estimate of the source depth of hollow-forming materials from the impact simulations. We will consider the implications of our revised estimate maximum hollow-forming material source depth for the formation and evolution of Mercury.

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