CALORIS IMPACT BASIN: EXTERIOR GEOMORPHOLOGY, STRATIGRAPHY, MORPHOMETRY, RADIAL SCULPTURE, AND SMOOTH PLAINS DEPOSITS. Caleb I. Fassett[1], James W. Head[1], David T. Blewett[2], Clark R. Chapman[3], James L. Dickson[1], Scott L. Murchie[2], Robert G. Strom[4], Thomas R. Watters[5]. [1]Dept. of Geol. Sci., Brown Univ., Providence, RI 02912, [2]JHU-APL, Laurel MD 20723, [3]SWRI, Boulder, CO 80303, [4]LPL, Univ. of Arizona, Tucson, AZ 85721 [5]CEPS-NASM, Smithsonian Inst., Washington, DC 20560 (Caleb_Fassett@brown.edu).

Introduction: The Mariner 10 mission first revealed the existence of the Caloris impact basin with an estimated diameter of 1340 km. Only the eastern third of the basin was imaged due to the flyby geometry of the Mariner 10 encounters. Among the questions that were raised by early analyses of the basin were its complete extent, the impact modification of pre-existing geology and topography, the history of basin filling and modification, and the origin (impact ejecta, impact melt, or volcanic) of its associated smooth plains (interior and exterior).

New MESSENGER image data of Caloris reveal that the basin is approximately 15% larger than previously estimated [1], and fitting a shape to its main topographic rim suggests that it is moderately elliptical (~1525 × 1315 km) [2]. New observations also allow us to reexamine the main geomorphological units related to Caloris along its rim and exterior to the basin that were originally mapped using Mariner 10 (the Caloris Group [3]). Three such units are apparent in both Mariner 10 and MESSENGER data: (1) the Caloris Montes (*cm*), which trace the main rim of the basin; (2) the Odin Formation (*co)*, "knobby" plains characterized by kilometer-scale hills; and (3) the Van Eyck Formation (*cvl/cvs*), radial sculpture and secondary craters associated with Caloris. One geomorphological unit mapped with Mariner 10 for which we see no strong evidence is the Nervo formation (*cn)*, which was originally interpreted as fallback ejecta in the intermontaine rim regions, but might instead be smooth plains that embay the rim materials (an interpretation plausible even with Mariner 10 data).

The first flyby of Mercury by MESSENGER has re-emphasized the importance of developing a consistent and thorough understanding of the stratigraphy related to the Caloris basin in order to understand the geological history of Mercury [e.g., 1-4].

Basin Sculpture: On the Moon, troughs and lineated terrain radiating from the Imbrium basin ("sculpture") were first described by G.K. Gilbert [5]. He interpreted this basin sculpture as primarily resulting from ballistic emplacement of ejecta and secondary cratering, consistent with discernable individual craters (secondaries) within the sculpture.

On Mercury, the Van Eyck Lineated (*cvl*) facies or Caloris sculpture [3] is typically expressed as a system of radial troughs, lineations, and crater chains, (width=5-30 km), distributed up to ~1500 km from the basin rim. Using MESSENGER data, we have mapped this radial sculpture (Fig. 1); the widespread extent of this facies makes it an ideal stratigraphic marker for the Caloris event over a large fraction of the surface of Mercury.

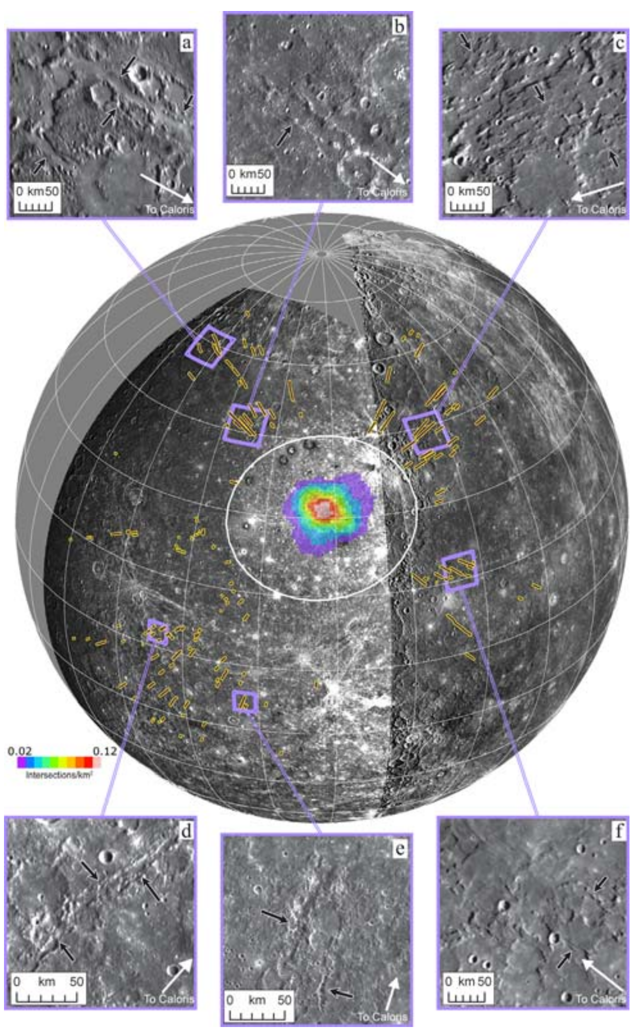
On the Moon, subtle variations have been mapped in the intersection point of Imbrium sculpture, suggested to be a result of it being an oblique impact [6]. To test whether a similar situation exists for Caloris, we have traced the radial sculpture back to the basin center using great circles to its locus of origin (see Fig. 1) [2]. Our mapping indicates that the source area for Caloris lineations is well confined to a near-circular region at the basin center, which may imply that Caloris was a less oblique impact than Imbrium. However, the moderate ellipticity (1525 × 1315 km; ellipticity ratio a/b =1.16) of the basin suggests that it still was probably somewhat oblique. Such an ellipticity has been shown to be typical for large (>1000-km) basins on many terrestrial planets [e.g., 7].

Origin of the Caloris Exterior Plains/Odin Formation: There are two primary hypotheses for the nature of the plains around Caloris: volcanic emplacement [e.g., 8] or impact-related ejecta deposition and sedimentation [9]. MESSENGER data from the first flyby has enabled initial assessment of these hypotheses [1,10,11,12]. The exterior plains are heterogeneous, with regions of dense kilometer-scale knobs (Odin Formation) typically found near the Caloris rim, with smooth plains surrounding and interspersed among these knobs. The geomorphic boundary between smooth and knobby materials is gradational. Color data suggest that the Odin Formation generally is low in reflectance like other members of the Caloris group (such as the Caloris Montes) [1,11]; other portions of the surrounding smooth plains have higher reflectance similar to the Caloris interior plains.

The origin of the Odin Formation is puzzling. It is limited in extent to the region around Caloris, suggesting a genetic link to the basin itself, akin to the knobby Alpes Formation around the Imbrium basin on the Moon. However, new crater counts using MESSENGER data [10] show that the Odin Formation and other surrounding plains have fewer craters than the plains on the Caloris interior.

Recently, we have also obtained a crater count for the Caloris basin itself using its rim region. These data (Fig. 2) suggest that the interior plains (which are older than the exterior plains) have considerably fewer craters than the Caloris basin rim, differing in cumulative crater frequency by a factor of two at a diameter of 20 km. The hypothesis most consistent with these observations is that the vast majority of both the Caloris interior and exterior plains are volcanic in origin. In this scenario, the characteristic appearance of the Odin Formation may result from differential burial of ejecta blocks by later plains, or the knobs may have an endogenic origin.

Comparison with Other Basin Deposits: The second MESSENGER flyby revealed a sizeable basin (centered at -33ºN, 87ºE, D=715 km) along the terminator of the incoming encounter hemisphere [13]. This basin has exposures of impact sculpture in its immediate surroundings at smaller scales than Caloris, especially to the northeast. However, geomorphological evidence suggests that most of its exterior has been resurfaced by smooth (volcanic) plains, with the exception of a region north of the basin rim. This interpretation is supported by the difference in crater density between the basin rim and surrounding exterior smooth plains. The basin exterior lacks evidence for a distinct knobby facies analogous to the Odin Formation, although there is knobby facies on its interior along a terrace at its northern and western margin. It appears that the stratigraphic relationships between this basin and most of its surroundings are similar to those of Caloris; in each case, basin ejecta are not widely exposed on the present surface.



Conclusions: (1) The Caloris Group defined on the basis of Mariner 10 data is broadly supported by MESSENGER data; (2) the Caloris basin is ~15% larger than previously estimated and may be moderately elliptical based on the most prominent sections of its rim; (3) sculpture (*cvl)* and secondaries (*cvs)* from Caloris can be traced over a large fraction of the surface of Mercury, and are thus a valuable stratigraphic marker for the basin-forming event; and (4) the Caloris interior and exterior plains are likely volcanic in origin, including the Odin Formation. The knobs or blocks characteristic of the Odin Formation may be Caloris-related and embayed by later volcanism, or may post-date the basin.

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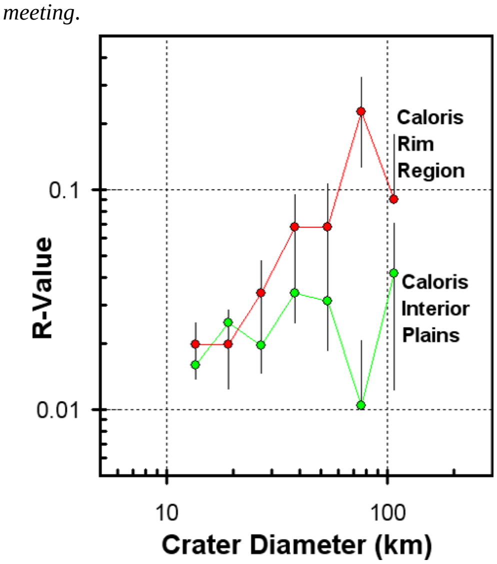

Fig. 1 (left). Mapping of the sculpture around Caloris (from Mariner 10 and MESSENGER). In the center of the basin is density plot of intersections found by extending great circle traces of the sculpture back to its source.

Fig. 2 (above). R-plot of crater counts for the Caloris basin rim and interior plains of the basin. These data show a large difference in frequency between the basin itself and the plains, as well as a substantial change in the slope of the two size-frequency distributions. The latter may be a result of changes in the impactor population during and after the late heavy bombardment [see, e.g., 10].