MERCURY'S CALORIS PLAINS: CONTINUTITY BETWEEN INTERIOR AND EXTERIOR PLAINS?

D. A. Rothery[1] , P. Mancinelli[2], L. Guzzetta[3] and J. Wright[1], [1]School of Physical Sciences, The Open University, Milton Keynes, MK7 6AA, UK (d.a.rothery@open.ac.uk), [2]Dipartimento di Fisica e Geologia, Università degli Studi di Perugia, via A. Pascoli 06123, Perugia, Italy, [3]INAF, Istituto di Astrofisica e Planetologia Spaziali, Rome, Italy.

Introduction: The smooth plains on the floor of Mercury's Caloris basin and those beyond the rim that almost entirely surround it are commonly accepted to be younger than the rim materials, and to be lava flows rather than impact melt. High resolution imaging shows that emplacement of interior and exterior plains was concurrent, with evidence of both inward and outward flow. In least one place the Caloris rim is breached by continuous smooth plains, seamlessly linking interior and exterior plains. The apparent spectral and compositional distinctiveness of interior and exterior plains is blurred on the 100 km scale and can be explained by interfingering of flow units less than a few 100 km long that tapped melt sources of different composition and/or depth inside and outside the basin followed by local mixing of regolith.

Caloris basin: Mercury's largest well-preserved impact basin is 1550 km in diameter (Figure 1). It has no formal name, but is usually referred to as 'the Caloris basin', from Caloris Planitia, which is the IAU-approved name of the 'smooth plains' that cover the basin floor, and the eastern part of its rim that is mapped as Caloris Montes. On a gross scale, the plains are spectrally [1] and compositionally [2] distinct from the plains outside the basin, though the effective spatial resolution of even the best X-ray spectroscopy [2] in this region is of the order of 100 km.

The inward-facing scarp marking the edge of the Caloris basin is up to 3 km above the level of the interior plains, notably along much of the southern rim. Elsewhere it is lower, and in a few places it lacks clear topographic expression. Where best exposed (least flooded by smooth plains) the scarp has a distinctive morphology, usually consisting of straight-sided re-entrants from less than 10 km to nearly 100 km in size.

We refer to the plains units inside and surrounding the basin as interior plains and exterior plains, respectively, while recognising that both can be legitimately described and mapped as 'smooth plains'. In agreement with most other authors we accept that these were emplaced largely by effusive volcanism prior to about 3.5 Ga ago [1, 3-6]. The vents or fissures through which these were erupted are not identifiable. We interpret the Odin Formation [4] as exterior plains embaying ejecta blocks.

Relative ages: Crater counting to determine the relative ages of the interior and exterior plains has proven intractable, despite claims that the exterior plains are slightly the younger of the two [7-9]. Here we adopt an alternative approach to determining the relationship between interior and exterior plains, by looking for volcanological and morphological evidence in the highest resolution images returned by MESSENGER. In our full study we have identified six areas of the Caloris rim where interior and exterior plains appear to be in contact. Here we illustrate two of them A and B, located in Fig. 1.

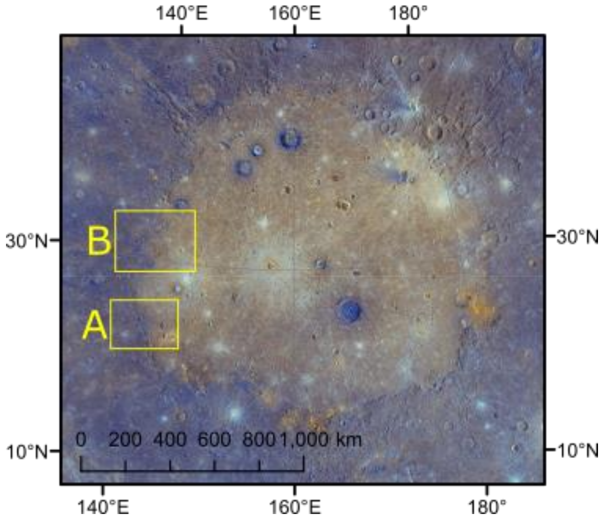

Fig 1 *MESSENGER enhanced colour view [5,7] of the Caloris basin, in which the interior plains are red. The boxes indicate areas of interest.*

Area A: This is a place where the exterior plains have most plausibly flowed towards the basin and descended over the rim to flood a re-entrant. This part of the Caloris rim was noted by [4] as containing 'evidence for channelized flow from the Odin-type plains into the basin'. Studied now at higher resolution (as good as 110 mpp) we find no narrow channels but a 50 km-wide largely flooded rim re-entrant (extending over 80 km outwards from the basin) into which exterior plains material appears to have spilled, carrying knobs up to 3 km in size up to 50 km into the basin (Fig. 2). The surface in the re-entrant itself is marked by 'stretch marks' in the form of grabens or steps at 2-6 km spacing, suggesting that the material flowing into the basin (descending <0.5 km vertically here) had a crust that became torn open but not totally disrupted, unless to form the knobs that are apparent at the distal end.

The most parsimonious explanation for all this is a single phenomenon: lava flow across characteristic rim architecture. This is consistent with features in common with some other examples not illustrated here. For this reason we favour it over alternatives such as the knobs on the basin floor having been emplaced by a landslide (we do not find similar fields of knobs on the interior plains near the openings of re-entrants that lack associated signs of inward flooding), or the 'grabens' on the flow surface being tectonic in origin. We find no evidence of flow fronts but the most distal knobs are within plains material that is red rather than blue, so the final flow event here was most likely outwards from the basin to embay an already-emplaced inward flow.

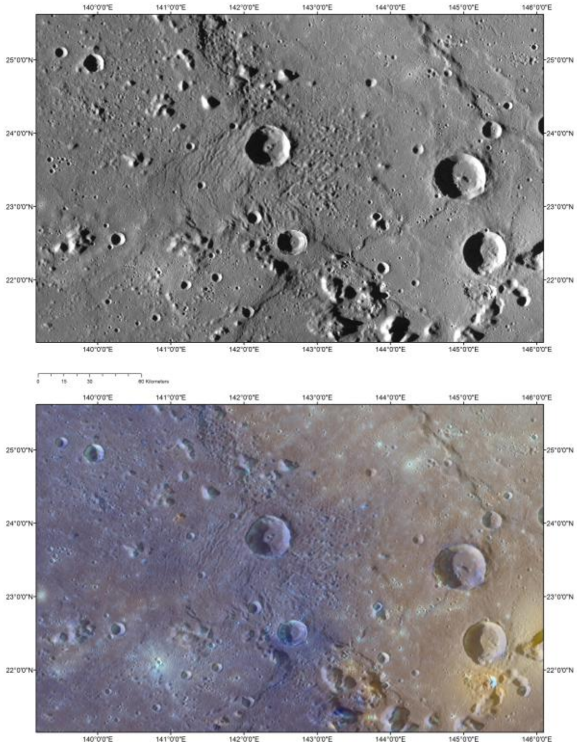

Fig 2 *Area A. Top: 166 mpp NAC mosaic. Bottom: 655 mpp WAC color overlaying 166 mpp NAC mosaic.*

Area B: Here the basin rim was evidently so low that smooth plains were able to overtop it completely. The interior plains are in contact with undoubted exterior plains [8,9]. The total width of the breach is about 400 km, but here we focus on the central 200 km (Fig. 3). Faced with the requirement to distinguish interior and exterior plains on a 1:3M quadrangle geologic map, [9] placed the contact along a morpho-tectonic feature mapped as a 'thrust – uncertain'. Our study of the highest resolution images of the 'contact' (14 mpp) gives no reason to interpret this as anything other than an unremarkable wrinkle ridge. The transition from 'red' interior plains to 'blue' exterior plains is particularly diffuse and patchy in this region. This may be partly, though we think certainly not completely, because of streaks of 'blue' ejecta from Raditladi, a 260 km diameter late Mansurian peak ring basin 1000 km to the west of the Caloris rim.

Local color changes show no relationship with this wrinkle ridge. This is a region where it appears one could walk from exterior to interior plains without crossing an identifiable boundary. The observed spectroscopic [1] and compositional [2] differences between exterior and interior plains could result from this plains volcanism having been fed by multiple vents or fissures spaced apart by a few hundred km, tapping into melt sources at different depths, and/or involving different degrees of partial melting, and/or assimilating crust of different composition during ascent.

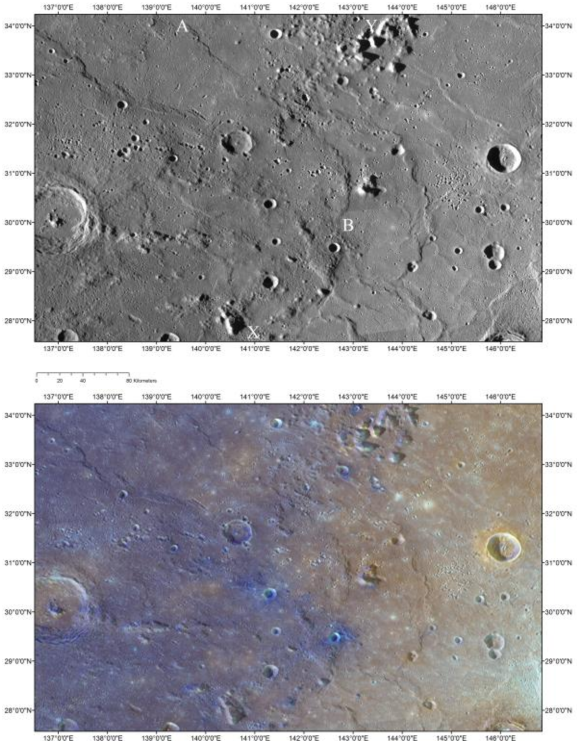

Fig 3 *Area B. Top: 166 mpp NAC mosaic. The Caloris rim runs through X and Y. A and B mark the ends of the tectonic featured used as the interior/exterior boundary in [9]. Bottom: 655 mpp WAC color overlaying 166 mpp NAC mosaic.*

References: [1] Ernst C. M. *et al.* (2015) *Icarus, 250*, 413–429. [2] Weider S Z. *et al.* (2015) *EPSL, 416*, 109-120. [3] Head J. W. *et al.* (2009) *EPSL*, *285*, 227-242. 1344–1345. [4] Denevi B. W. *et al.* (2013) *JGR, 118*, 891-907. [5] Murchie.S. L. *et al.* (2015) *Icarus 254*, 287-305. [6] Byrne P. K. *et al.* (2016) *GRL 43*, doi:10.11002/2016GL069412. [7] Denevi B. W. *et al*. (2009) *Science, 324*, 613-618. [8] Goosmann E. *et al*. (2016) *LPS* 47, 1254. [9] Mancinelli P. *et al.* (2016) *JoM*, *12*, 227-238.