BEAGLE RUPES – EVIDENCE FOR A BASAL DECOLLEMENT OF REGIONAL EXTENT IN MERCURY'S LITHOSPHERE. David A. Rothery[1] and Matteo Massironi[2], [1]Dept. of Earth & Environmental Sciences, The Open University, Milton Keynes, MK7 6AA, UK (d.a.rothery@open.ac.uk), [2]Dipartimento di Geoscienze, Università degli Studi di Padova, via Giotto 1, 35137 Padova, Italy (matteo.massironi@unipd.it).

Introduction: Study of images returned by Mariner 10 [1], [2] and MESSENGER [3] shows that Mercury's tectonic history, although ancient, is also complex. Mercury's most characteristic tectonic features are lobate scarps, generally interpreted to be surface expressions of thrust faults recording a cooling-related decrease in global radius [4], [5]. North-south trending scarps near the equator may have exploited weakness developed during tidal despinning by relaxation of an equatorial bulge [6], [7]. However, neither a single episode nor a single mechanism can explain Mercury's tectonics, even if we focus on features classified as lobate scarps and discount clearly diverse features such as the extensional troughs in the Caloris Basin [8] and the smaller-scale wrinkle ridges best expressed in the lavas of the smooth plains [4], [9].

Beagle Rupes: Here we assess the fault geometry associated with Beagle Rupes, a prominent lobate scarp imaged by MESSENGER outbound from its January 2008 fly-by [3]. It has a 260 km long north-south trending segment (A-B on Fig. 1) with characteristics common to mercurian lobate scarps in general. This segment consists of two arcs, convex towards the downward side of the scarp, and meeting at a cusp as in the arcuate lobate scarps (e.g., Discovery Rupes) that were first distinguished by Dzurisin [1]. Like them it is almost certainly a surface expression of thrusting, which would be westward-directed in this example.

However, unlike most previously described examples [10], scarp height and inferred displacement do not gradually decrease to zero at either end of this segment. Instead the north-south segment is joined at its north end to a straight scarp trending east-north-east (B-C on Fig. 1) and at its south end to a straight scarp trending east-south-east (A-D on Fig. 1). At their western ends, these two straight segments curve smoothly to join the north-south lobate segment. The whole scarp (D-A-B-C) bounds a trapezoidal region extending at least 200 km eastwards from the north-south scarp and measuring at least 470 km from north to south at its poorly-defined, open, eastern end.

The east-west shortening implied by the lobate scarp A-B makes it unlikely that either of the diverging straight segments B-C or A-D can represent pure compression. More likely, westward motion of a thrust sheet fronted by the main Beagle Rupes escarpment would require these to be transpressive lateral ramps, right-lateral on B-C and left-lateral on A-D.

We interpret the offset across these straight segments to decrease with distance behind the main scarp A-B. However, the visible tips (C and D) of the two lateral ramps are not the limit of displaced terrain. About 300 km behind the main scarp, the southern lateral ramp (A-D) appears to be over-ridden by later lobate scarps that may represent 'out of sequence' thrusts [11]. The continuous length of the northern straight segment (B-C) is only about 150 km, beyond which two parallel structures (part scarp, part ridge) mark possible transpressive faults, to which the motion could be transferred for up to a further 300 km before evidence is lost beneath the ejecta blanket from the younger, 100 km, crater Eminescu.

Visual evidence for the amount of displacement across the main scarp (A-B) is poor. The large basin Sveinsdóttir is cut by the scarp, but it had such an elongated initial shape that its current outline provides no clues to the amount of displacement. Based on a single 15 km crater cut by the northern part of the scarp Solomon et al. [3] suggest a shortening of 'at least one to several km'. Examining the same crater on the highest resolution NAC frames CN0108826201M and …206M, we estimate shortening of 3 km if this crater was initially circular in outline, but no more than 1 km if the crater was of the same non-circular shape as a nearby example. A linear chain of coalesced sub-4 km secondary impact craters radial to the northeastern half of Sveinsdóttir is cut by the straight scarp midway between A and D on Fig. 1, and here (on high resolution NAC frame CN0108826004M) the maximum plausible left-lateral offset is not more than 2 km.

The shortening across the main scarp falls within 0.3-3.2 km range of estimates by Watters et al. [12] for ten mercurian lobate scarps derived from measured scarp heights and assumed fault-plane dip of 25°. Watters et al. [10, 12, 13] estimate displacement from the translation necessary to restore the ground surface to horizontal. This may apply to Beagle Rupes. However, Watters et al. [13] model planar thrust faults dipping at 30-35° and dying out at 35-40 km depth, implying a thrust sheet extending only 50-70 km behind the scarp, whereas in the case of Beagle Rupes the pattern of faulting described above shows that the translated block extends at least 200 km, and possibly

>400 km east of the scarp. If Beagle Rupes results from westward movement of a thrust sheet, there must be a continuous fault surface at depth stretching between A-D and B-C, and dying out either near the line C-D or further east. Unless it propagated below the elastic lithosphere, estimated to have been 25-30 km when lobate scarps were forming [14], the dip of this fault surface must become shallower with depth (listric fault geometry). We therefore suggest that at least the whole area bounded by A-B-C-D on Figure 1 is underlain by a basal decollement, and that westward displacement of the hanging-wall block is greatest near A-B, gradually dying out toward the east. We have no evidence for the near-surface dip of the lateral ramps A-D and B-C, but it is geometrically reasonable that it is steeper than the dip at the thrust-front A-B.

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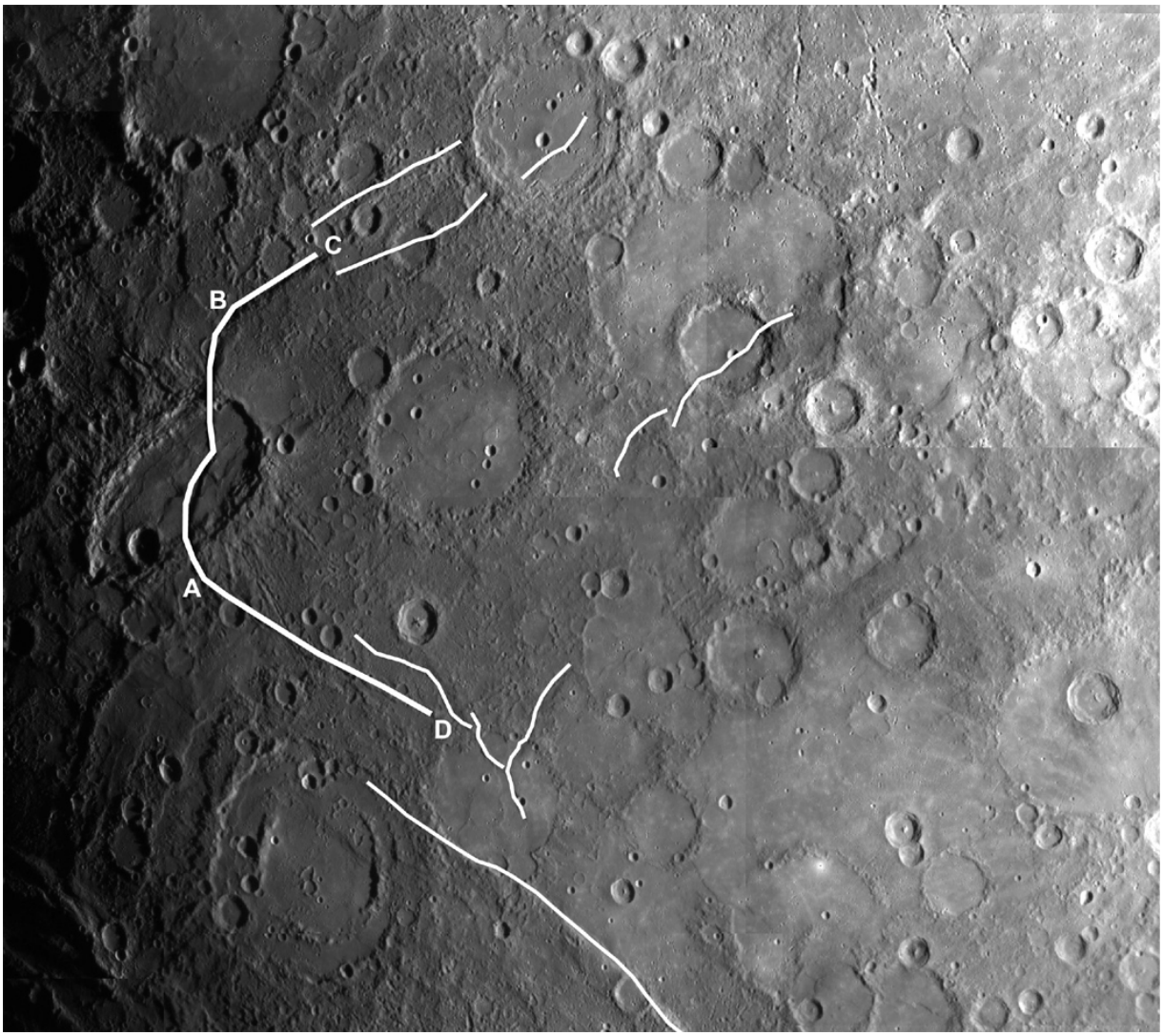

Figure 1: Uncorrected mosaic of MESSENGER NAC images, approximately 850 km from east to west. Beagle Rupes is marked as a bold line D-A-B-C. Scarps and other disturbances interpreted as faults or thrusts are shown as finer lines. The linear scarp in the south is an older (probably unrelated) feature, embayed by smooth plains [3].