FAULT RESTRICTION IN THE CALORIS SMOOTH PLAINS: IMPLICATIONS FOR MECHANICAL STRATIGRAPHY Christian Klimczak[1], Carolyn M. Ernst[2], Paul K. Byrne[1], Sean C. Solomon[1], Thomas R. Watters[3], [1]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015, USA, cklimczak@ciw.edu; [2]The Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA; [3]Center for Planetary Sciences, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560, USA.

Introduction: The Caloris basin, the largest known impact basin on Mercury, is filled with spectrally distinct smooth volcanic plains [1-3] that show evidence for deformation, including both extensional and contractional landforms, formed after plains emplacement. The major tectonic structures are comprised of graben and wrinkle ridges that display complex map patterns and crosscutting relationships [4-7]. Both graben and ridges are characterized by a mix of radial and concentric orientations and polygonal patterns [8]. The central radial graben, termed Pantheon Fossae, were previously described from images obtained during the first MESSENGER flyby [e.g., 2,7,9]. Higher-resolution images from MESSENGER's orbital observations (Fig. 1) allow more detailed descriptions and analysis of Pantheon Fossae and associated radial graben. In particular, shadow measurements across the graben in conjunction with individual Mercury Laser Altimeter profiles [10] allow the determination of graben floor depths and, therefore, the displacements on the shadowed faults. The fault displacements combined with map patterns of the graben reveal a complex evolution of graben growth, bringing better insight into their formation as well as contributing toward the characterization of the mechanical and stratigraphic layering of the Caloris smooth plains.

Fault geometries and displacements: Observations and analyses from flyby images have shown that there are two sequential sets of graben, distinguishable by crosscutting relationships and a distinct difference in widths. A few wide graben cut through a larger graben population with constant widths of 2-3 km along their lengths [11]. Coverage of the Caloris basin with higher-resolution images confirms the crosscutting relationships and shows that there is a greater variation in graben geometries than seen from the flybys.

Graben-bounding faults are either isolated or linked to other faults, as indicated by the presence of relay ramps in the stepover regions between two faults (Fig. 1b). Graben consist of a master fault and either a single antithetic fault or several segmented antithetic faults, showing that longer graben developed by the coalescence of smaller faults (Fig. 1b). Both isolated and linked faults are also evident from displacement profiles. The displacement profiles of 12 representative faults show linked fault arrays (Fig. 2) associated with the graben. Fault linkage is evident by substantial overlap of some faults, areas where the greatest cumulative displacements (grey-shaded areas) are seen. In the examples shown (Fig. 2b,c), maximum cumulative displacements occur near the middle of the fault array, whereas maximum displacements on individual faults can be skewed toward the fault tips (e.g., Fig. 2c) [12].

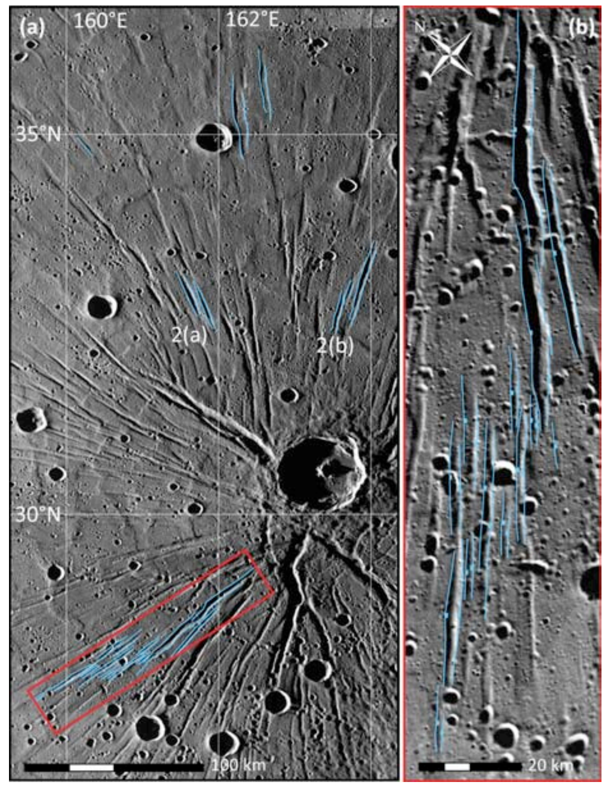

Figure 1. Graben of Pantheon Fossae, central Caloris basin. (a) Overview of the fault systems with displacement profiles in Fig. 2. (b) Detailed view of linked graben.

Many of the smaller faults have peaked displacement profiles (e.g., Fig. 2c), indicating that they are confined to a single mechanical layer [12-14], whereas some large faults have uneven profiles, suggesting that they represent several small faults that coalesced into a larger structure. A substantial number of faults have plateaued profiles (e.g., Fig. 2), diagnostic of vertical restriction to a mechanical layer [e.g., 12-14]. All restricted faults show profiles with displacements plateauing at ~200-250 m (Fig. 2), pointing to a common depth of faulting for these faults. In addition, higher displacements on the faults are found closer to the center of the Caloris basin (Fig. 2c), suggesting that faults first formed there and propagated outward toward the basin rim.

Comparison to stratigraphy from crater excavation depths: Fault restriction and depth of faulting provide insight into mechanical layering of the units and, hence, can yield estimates for the thickness of the unit in which they form. The approximate depths of faulting for the graben can be inferred from graben widths [11,15]. A compilation of the depth of faulting for more than 130 graben in Pantheon Fossae inferred from graben widths indicated that faults could be vertically restricted to two successive stratigraphic or mechanical units at ~3 and ~13 km depth [11]. The presence of plateaued displacement profiles from this study confirms fault restriction to a mechanical layer, with depths of faulting suggesting a layer boundary at ~3.5-4 km depth. Independent of these arguments, the impact excavation of spectrally distinct units in the Caloris basin interior suggests that there is a compositional boundary between high-reflectance red plains and underlying low-reflectance material present at 2.5-4 km and that low-reflectance material occurs as deep as ~ 10 km [3]. The good agreement between the two studies validates both approaches to inferring the presence of layering in shallow planetary crusts.

References: [1] Robinson M. S. et al. (2008) *Science, 321,* 66. [2] Murchie S. L. et al. (2008) *Science*, *321*, 73. [3] Ernst C. M. et al. (2010) *Icarus, 209,* 210. [4] Strom R. G. et al. (1975) *JGR*, *80*, 2478. [5] Melosh H. J. and McKinnon W. B. (1988) in *Mercury*, Vilas F. et al. (eds.) Univ. Arizona Press, 374. [6] Watters T. R. et al. (2005) *Geology*, *33*, 669. [7] Watters T. R. et al. (2009) *EPSL*, *285*, 309. [8] Byrne P. K. et al. (2012), *LPS, 43*, this mtg. [9] Head J. W. et al. (2008) *Science, 321,* 69. [10] Zuber M. T. et al. *Science*, submitted. [11] Klimczak C. et al. (2010) *Icarus, 209,* 262. [12] Schultz R. A. et al. (2010) in *Planetary Tectonics,* Watters T. R. and Schultz R. A. (eds), Cambridge Univ. Press, 457. [13] Soliva R. and Benedicto A. (2005) *JSG, 27,* 317. [14] Polit A. T. et al. (2009) *JSG, 31,* 262. [15] Schultz R. A. et al. (2007) in *The Geology of Mars: Evidence from Earth-Based Analogues,* Chapman, M. G. (ed), Cambridge Univ. Press, 371.

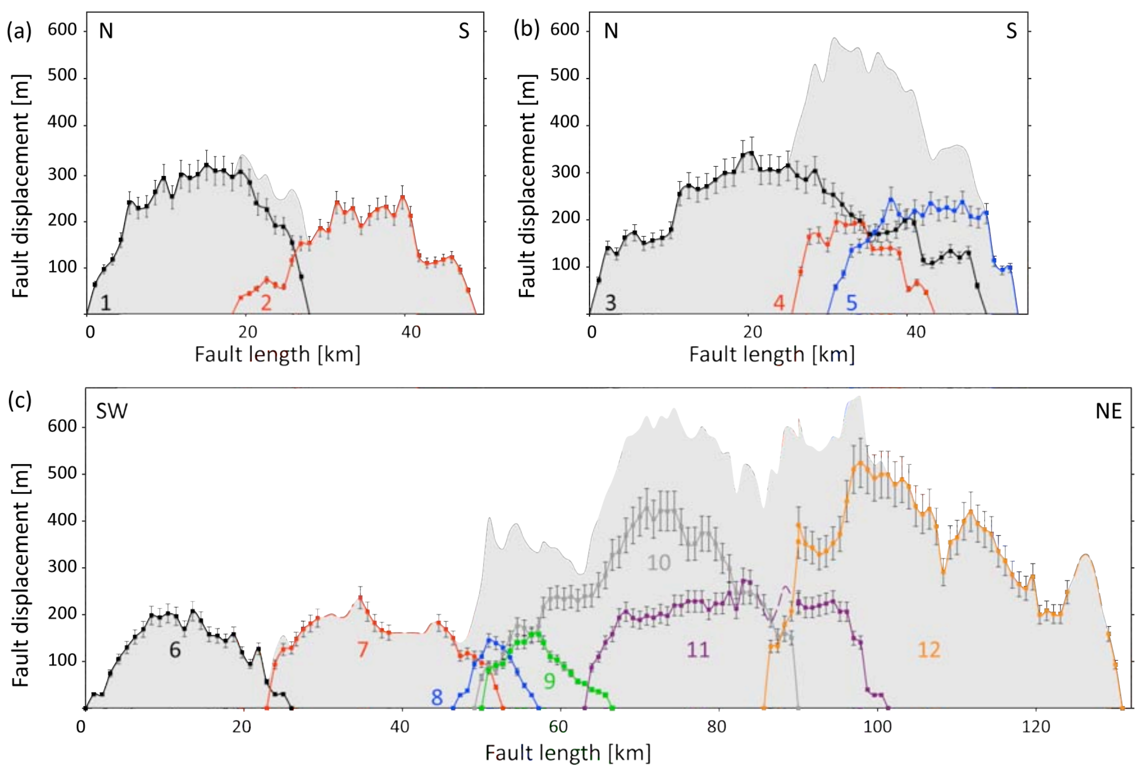

Figure 2. Fault displacement profiles for three fault arrays. Displacements along individual faults are shown with errors equal to about 10% of the cumulative displacements on all faults in a system (grey-shaded area). (a) Two faults with minimal overlap. (b) Three faults with large overlap. (c) Complex linked fault system.