CALORIS BASIN, MERCURY: TECTONIC DEFORMATIONAL HISTORY FROM AN ANALYSIS OF CROSS-CUTTING SRUCTURES. A. B. Cunje[1] and R. R. Ghent[1, 2]. [1]Department of Earth Sciences, University of Toronto, ON, Canada (alister.cunje@mail.utoronto.ca), [2]Planetary Science Institute, Tucson, AZ, USA.

Introduction: The Caloris Basin on Mercury, measuring approximately 1,640 km in diameter, is well known for being both the largest recognized impact basin and host to the most tectonically deformed smooth plains (the Caloris Planitia) on the planet [1]. The deformed basin and interior plains feature several distinct suites of tectonic structures. Contractional wrinkle ridges, dominantly concentric in orientation, and graben of radial, concentric and no-preferred orientation can be observed within different regions at various radial distances from the basin center.

Each of these distinct structural features is representative of a set of relative azimuthal and radial strains observed at their location, and we describe the relative timing of these structures through the analysis of the instances and locations where they interact in cross-cutting relationships. While previous research has defined discrete stages of deformation as responsible for each individual suite of structures [2, 3], we demonstrate that certain pairings of orthogonal structures may have formed contemporaneously as evidenced by the ambiguity of their observed cross-cutting relations and the strain compatibility of the structures involved. Overall, we seek to establish a more rigorous history of deformation for the basin.

Basin Tectonic Structures: Figure 1 shows a structural sketch map highlighting each of the suites of structures defined below, and the areas where we analyzed cross-cutting relationships.

(a) Contractional Structures. The contractional wrinkle ridges (WR) found throughout the basin are surface expressions of thrust faults creating folded ridges and are attributed to formation due to the contraction associated with the cooling of the planet's interior [4, 5]. The ridges are dominantly concentric in orientation throughout the basin with the exception of those found near the basin rim where they have formed with a less evidently preferred orientation. The concentric orientation is indicative of radial contraction, while a lack of preference is representative of relatively equal magnitudes of azimuthal and radial contraction. Lobate scarps, also thrust-fault structures, are observed towards the basin rim but do not interact with other structures and are not included in this analysis.

(b) Extensional Structures. Three distinct sets of extensional graben structures can be observed throughout the basin. The basin-radial graben (RG) of Pantheon Fossae (PF) are an array of structures formed by azimuthal extension. They originate at the basin center and extend to approximately half of the basin radius. A subset of the RG can also be observed near Apollodorus crater near the basin center, and consists of a few distinctly wider graben with slightly differing orientations. This subset has been defined as Set 2 RG, and the remaining majority of similar sized RG as Set 1 [6].

Basin-concentric graben (CG), structures formed by radial extension, are observed at a range of ~0.45*r*-0.55*r* [1], and appear to bound the extent of the RG, though some overlap in the presence of structures allows for cross-cutting analyses. Between the extent of the concentric graben and the randomly-oriented wrinkle ridges, an array of graben form extensional polygonal troughs (PT), and show a distinct lack of preferred orientation, being basin-radial, concentric, or oblique [1, 7]. The PT decrease in overall size with greater proximity to the basin rim, displaying a related drop in the magnitude of extensional strain. The graben have been interpreted to have formed by cooling and thermal contraction of lava flow units [4]. Due to the close proximity of the polygonal troughs and the concentric graben, and gradual change in graben orientation, PT are grouped with the CG for the purposes of temporal relations.

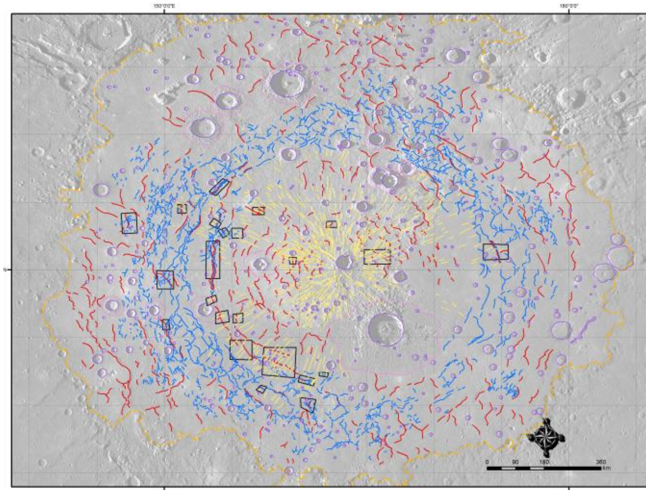

Figure 1 – *Structural mapping of Caloris basin tectonic features: Red (WR), blue (CG/PT), yellow (RG), orange (Basin rim), and black outlines of cross-cutting interactions examined in tally.*

Cross-cutting Analysis: Through the use of high-resolution images taken by the MESSENGER satellite, we analyzed areas showing interactions between the tectonic structures on a case-by-case basis in order to determine the consistency of relative timing between each suite of structures on a broad scale. We examined interacting structures in different areas of the basin and collected a tally (**Table 1**). We assigned a value of +1 to structures displaying the commonly assumed sequence of contractional features before extensional features [3]. We assigned a value of -1 to relations showing the reverse temporal relation, and a 0 to ambiguous relationships. Thus, relationships showing a large positive total value would confirm the notion that contraction always precedes extension, while a near-zero or negative value would indicate further complexity and deviation from this deformational history.

WR→RG: The relation found between WR and RG suggest that the timing of their formation is ambiguous and potentially contemporaneous; interactions do not show a consistent relation with one feature predating another throughout the basin. At some locations some ridges appear to be cut by graben, while at others graben appear to be folded by younger ridges. *WR→CG/PT:* The WR are consistently cut by CG/PT at every instance observed, confirming that the radial extension occurred at a later time than the radial contraction. *RG→CG:* The CG seem to have an ambiguous timing relation with the RG, with most interactions being difficult to determine and with several instances suggesting that the RG actually cut and post-date existing CG.

Long.(°E)	Lat.(°N)	WR→RG	WR → CG/PT	RG→CG
147.4	33.7	/	+1	/
155	33	+1	+1	-1
155.2	24.6	-1	/	/
155.8	24.5	+1	/	/
158.4	24	+1	/	/
158.4	23	-1	/	/
160.6	21.8	0	+1	-1
165.5	30.8	+1	/	/
Subtotal		+2/7	+3/3	-2/2
Total		+5/16	+11/11	-2/8

Table 1: Example tally for selected interactions, and total from all sites highlighted in Fig.1.

Structure Orientations and Compatibility: The orientations of the structures shown in **Fig.1** when plotted on a Rose diagram support the temporal relationships listed above. The majority of RG are oriented at ~60°/240°, and are generally orthogonal to the concentric WR commonly orientated at ~150°/330°. Thus a timing history of contemporaneous deformation is plausible for these two sets of structures because they are strain compatible; azimuthal extension and radial compression can occur over similar time periods, as can azimuthal and radial extension in the case of PTs or CG and RG. Where CG meet WR radial compression and extension cannot occur simultaneously and a minimum of two stages of deformation must be established, as has previously been proposed [2, 3]. However, due to the ambiguity/simultaneity between the RG and WR, and between RG and CG even though the CG consistently postdate the WR, an interpretation can be made of a progressive deformation resulting in RG over both time periods during which the WR and CG formed discretely, one after the other.

Basin Strain Profile: As previously mentioned the structures observed at varying sections of the basin are indicative of different relative sets of azimuthal and extensional strains. The Caloris basin generally hosts areas with structures that are strain compatible, as is the case with the RG and concentric WR; however, areas of incompatibility can also be found where CG cut/bisect existing concentric WR. We will quantify the extensional and contractional strains exhibited by features of both azimuthal and concentric orientation to provide a strain profile of the basin that displays the strain compatibility, or incompatibility, of the observed sets of structures as a function of radial distance from the basin center. This will reinforce the deformational history defined here and provide a base to which future formation models can reference when applying stresses to deform the basin.

Basin Deformation History and Implications: The timing of structures interpreted here is complimentary with certain theories describing the development of the Caloris basin. In particular, it supports the doming/uplift formation hypothesis for PF [6] as it would be expected that the produced azimuthal extension would occur at greater radial distances at later periods in accordance with increased doming over time. The Caloris basin has also been hypothesized as a multi-ring basin with buried rings [1], and if this is the case the ridges produced by the burying of these rings could be the source of the first WRs in areas of strain incompatibility. Through these evidences a final deformational history can be constructed as follows: WR (Buried basin rings) → WR+RG → CG/PT + RG.

References: [1] Byrne P.K. et al. (2013) LPS, 44, abstract #1261. [2] Basilevsky et al. (2011) *Solar Systems Research*, 45, 471-497. [3] Murchie S.L. et al. (2008) *Science, 321, 73.* [4] Watters T.R. et al. (2012) *Geology, 40; 12; 1123-1126.* [5] Watters T.R. and F. Nimmo. (2010) *Planetary Tectonics*, Chapter 2– Mercury. Cambridge University Press. [6] Klimczak C. et al. (2010) *Icarus. 209; 262-270.* [7] Watters T.R. et al. (2005) *Geology, 33; 8; 669-672.*