LARGE-SCALE CRUSTAL DEFORMATION ON MERCURY. Paul K. Byrne[1], A. M. Celâl Şengör[2], Christian Klimczak[1], Sean C. Solomon[1], and Thomas R. Watters[3]. [1]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington DC, 20015, USA (pbyrne@dtm.ciw.edu); [2]Department of Geological Engineering, Istanbul Technical University, İstanbul, Turkey; [3]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington DC, 20013, USA.

Introduction: The *MESSENGER* mission's campaigns to image nearly the entire surface of Mercury at a resolution of 250 m/px or better, and to determine the topography and gravity fields of its northern hemisphere, provide a new opportunity to assess large-scale crustal deformation on the innermost planet. Building upon previous observations of tectonic landforms on Mercury [e.g., 1,2], we have identified several laterally contiguous sets of lobate scarps and high relief ridges, together with candidate monocline and anticline landforms, of considerable length that we interpret as systems analogous to terrestrial fold-and-thrust belts. One such system extends for over 40° of arc (some 1,700 km) across Mercury's northern hemisphere (**Fig. 1a**); another example ~1,000 km long is located in the southern hemisphere (**Fig. 1b**).

Observations: Mercury Dual Imaging System (MDIS) [3] mosaics and gridded Mercury Laser Altimeter (MLA) [4] data combined within a geographical information system (GIS) show a correlation in several places between the broad thrust systems and long-wavelength topography. In particular, many of these systems on Mercury border high-standing terrain, a relation most evident between 30° N and 70° N, where MLA data have documented large regions of high topography [4]. Along such borders, the lobate scarps display a generally consistent sense of vergence outward onto adjacent lower-lying terrain (**Fig. 2**).

Strain generated by planetary contraction accommodated by the fold-and-thrust belts may be greater than previous estimates [1,5,6]. On the basis of restored cross-sections derived from several MLA profiles across the lobate scarps, we find horizontal displacements of up to 15 km in the thrust-slip direction. Additionally, analysis of craters deformed by thrust faults suggests that while some impact features show little deformation, others have been shortened by as much as 12 km. Moreover, MLA gridded data show that some large craters peripheral to high-standing topography are now inclined toward adjacent lows.

Most low-lying areas in Mercury's northern hemisphere consist of volcanic smooth plains deposits [7], whereas many high-standing regions appear to be older, heavily cratered terrain. The dominant tectonic landforms on both terrain types were formed by shortening (with the plains being dominated by wrinkle ridges) [6,8]. The individual contractional structures on smooth plains are generally shorter in length, have lower vertical relief than lobate scarps, are more densely distributed, and thus appear to have each accommodated less horizontal shortening per structure, than those on the heavily cratered terrain.

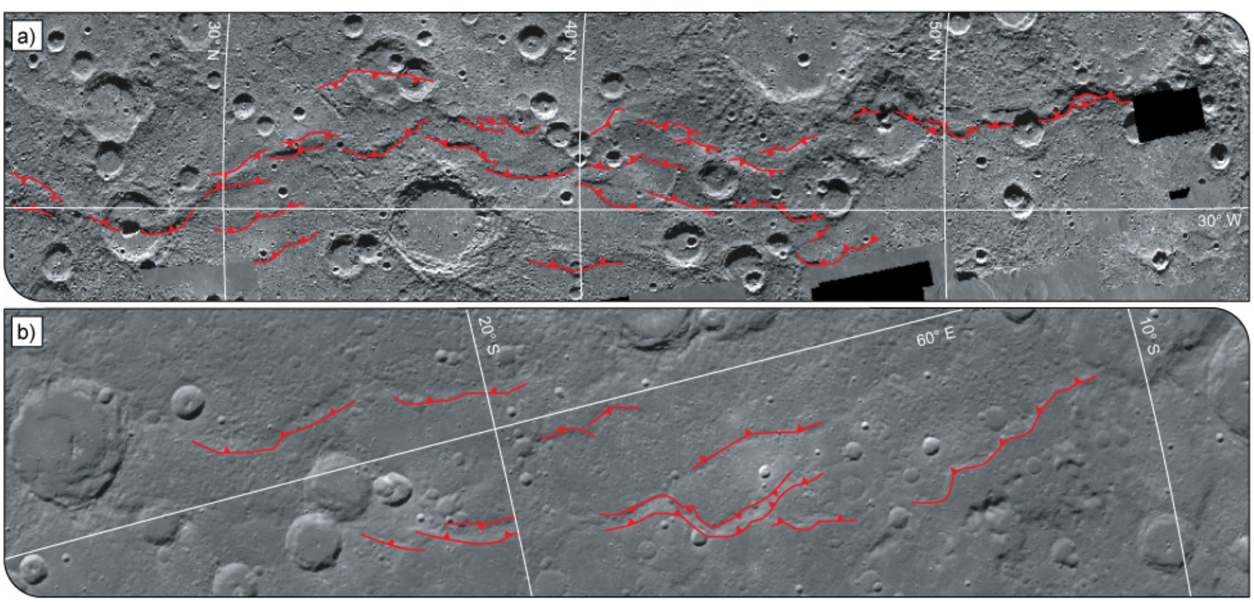

Fig. 1. Tectonic systems interpreted as fold-and-thrust belts on Mercury (from MDIS 250 m/px orbital data). Thrusts are traced in red; the triangles point down-dip. **a)** A 1,700 km-long thrust system at mid-northern latitudes that consists of lobate scarps, high-relief ridges, and potential monoclines and anticlines. **b)** A similar 1,000 km-long belt in the southern hemisphere.

In addition, *MESSENGER* observations have documented a broad spatial correlation between areas of high topography and positive gravity anomalies in Mercury's northern hemisphere [9], and *MESSENGER* X-Ray Spectrometer (XRS) spectra suggest that at least some heavily cratered terrain is more magnesian than the basaltic northern smooth plains [10,11].

Implications: On the basis of geophysical observations, the large expanses of high-standing topography on Mercury are interpreted as regions of thicker crust than surrounding areas [9]. Some of these thicker crustal blocks are bounded by the systems that we interpret as fold-and-thrust belts. That these belts are visible today indicates either that they formed after the late heavy bombardment (LHB) of the inner Solar System [e.g., 12] or, if they formed earlier, that they remained active into later eras.

In either case, these large-scale thrust systems may have isolated the thicker crustal blocks from neighboring thinner portions of Mercury's crust. Under this scenario, the bounding fold-and-thrust belts served as sites for localization of lithospheric shortening (in response to the interior cooling and global contraction of the planet [e.g., 13]). As tangential shortening proceeded, thicker crustal blocks overthrust adjacent low-lying terrain [*cf.* 14], possibly contributing to the observed tilts of nearby impact crater floors. The possibility of greater shortening across these bounding systems than recognized earlier would bring estimates of observed planetary contraction closer to those predicted by geophysical models for interior cooling [13].

As fold-and-thrust belts do not border all regions of high-standing topography, we view the general distribution of thicker crustal portions on Mercury as a function of several processes, both endogenic (e.g., mantle dynamics, interior cooling) and exogenic (e.g., bolide impact, tidal despinning [15,16]) in nature. Such a combination (interior cooling together with despinning, for example) suggests that at least part of the pattern of thicker crust might have been established early in the planet's history, before the LHB. Since more than one process could account for the fold-and-thrust belts, these tectonic systems may also pre-date the LHB.

Finally, the contrast in size, amplitude, and density of tectonic structures between the smooth plains and the heavily cratered regions may reflect a difference in mechanical and rheological properties between the two terrain types [e.g., 17]. In particular, the fold-and-thrust belts bounding the crustal block massifs likely developed from detachments that root to deep basal décollements, whereas the many-layered volcanic smooth plains accommodated shortening at much more shallow levels.

Concluding remarks: Large-scale crustal deformation on Mercury may involve, in places at least, substantial horizontal shortening localized along fold-and-thrust belts that border blocks of high topography and thick crust. Although this conclusion is based on analyses of high-resolution images and measurements of topography and gravity that are restricted to the planet's northern hemisphere, we predict that similar relationships will characterize Mercury's southern hemisphere. With improved topographic coverage from laser altimetry [4], stereo photogrammetry [18], occultations [19], and limb imaging [20], this hypothesis can be tested for Mercury's contractional history on a global basis.

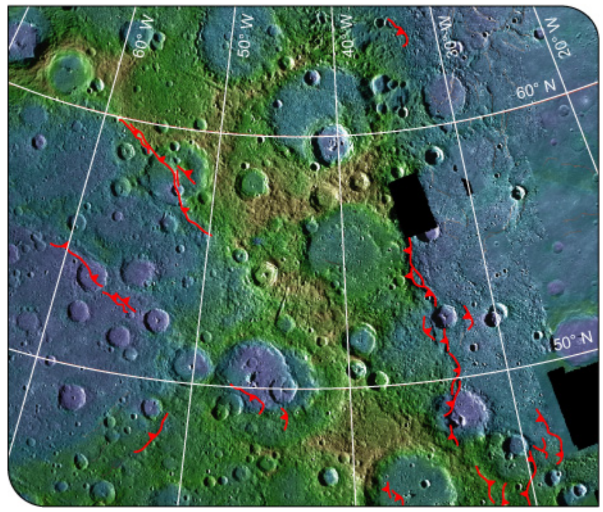

Fig. 2. MLA topography on an MDIS mosaic, showing generally consistent outward vergences along thrust faults bordering an area of high topography (structures as in **Fig. 1**).

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