**PRELIMINARY EVIDENCE FOR RECENT TECTONIC ACTIVITY ON MERCURY REVEALED BY A GLOBAL POPULATION OF EXTENSIONAL GRABENS.** B. M. Man[1], D. A. Rothery[1], M. R. Balme[1], S. J. Conway[2], J. Wright[3], [1]The Open University, Milton Keynes, MK7 6AA, UK, [2]Nantes Université, Université d'Angers, Le Mans Université, CNRS UMR 6112 Laboratoire de Planétologie et Géosciences, 44322 Nantes Cedex 3, France, [3]European Space Agency (ESA), European Space Astronomy Centre (ESAC), Camino Bajo del Castillo s/n, 28692 Villanueva de la Cañada, Madrid, Spain.

**Introduction:** Shortening structures including lobate scarps, wrinkle ridges and high relief ridges are found across the surface of Mercury as first identified by Mariner 10 and later confirmed by MESSENGER (Mercury Surface, Space ENvironment, GEochemistry and Ranging). It is widely held that these structures are the surface manifestations of thrust faults and associated folding that have formed due to lithospheric horizontal compression [**1**,**2**]. It is generally accepted that shortening structures form as a result of global contraction caused by secular cooling [**3**,**4**], however, their formation may also be ascribed to true polar wander [**5**], tidal despinning [**6**,**7**], mantle overturn [**8**] or a combination of some or all of these processes [**9**–**11**]. Regardless of the formation causation process(es), tectonism on Mercury is predicted to be taking place into the present day [**1**,**10**,**12**–**16**]. That being said, the only documentation of recent tectonic activity on Mercury is the identification of 39 pristine <10 km lobate scarps in the northern hemisphere [**15**] observed in Mercury Dual Imaging System (MDIS) [**17**] Narrow Angle Camera (NAC) images and 14 lobate scarps that crosscut Kuiperian (~280 Ma) craters [**18**].

We present the results of our global survey for extensional grabens on shortening structures and provide substantial new evidence of widespread, geologically recent tectonic activity on Mercury.

1. We have produced a new global tectonics database (**Fig 1**).
2. We filtered and processed all NAC frames of 150 m/pixel or better that intersected the structures in our database (1). We then analyzed every such frame and recorded extensional grabens (**Fig 1**).
3. We quantify the depths of the grabens by shadow measurements [**19**] and displacement-length calculations in order to infer an age based on the theorized rate of infilling.

**Data:** All the data used in our investigation were sourced from NASA's Planetary Data System Geosciences node and Cartography and Imaging Sciences node. For tectonic mapping (see methods) we used the version 1.0 monochrome moderate solar incidence angle (~74°) BDR as the basemap. The global mosaic has a resolution of ~166 m/pixel (256 pixels per degree) and was used in conjunction with ancillary MDIS products including the global Mercury Laser Altimeter and stereo-derived Digital Elevation Models (665 m/pixel) and monochrome high-incidence-angle (~78°) tiles (~166 m/pixel). For the global extensional grabens survey, we used NAC images that intersect the tectonic structures from our database.

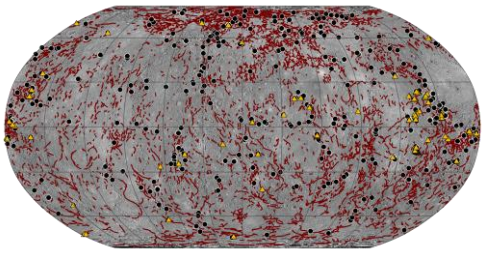

*Figure 1 Robinson projection of Mercury. Red lines = tectonic structures. Yellow triangles = confident extensional grabens. Black circles = tentative extensional grabens.*

**Methods:**

1. Tectonic Mapping: Building upon previous databases [**3**,**4**] we mapped all shortening structures in ArcGIS at a consistent 1:500,000 drafting scale, placing vertices every 2000 m using the streaming function. We mapped structure traces as polylines along breaks in slope. We have not mapped all tectonic structures within the Caloris basin, as likely basin-related features are not of interest to our investigation. Structures that cut the Caloris basin or were part of a sequence of structures that crosscut the basin rim were mapped.
2. Graben survey: We selected all NAC frames 150 m/pixel or better that intersected the mapped tectonic structures. We used JMARS (Java Mission planning and Analysis for Remote Sensing) [**20**] to query and ArcGIS to filter the 93408 NAC frames to 25489 that intersected our tectonic structures. We then downloaded and processed the images using the USGS ISIS3 (Integrated Software of Imagers and Spectrometers version 3). Next, we looked at each NAC image for each structure, on a quadrangle-by-quadrangle basis, where we identified and recorded extensional grabens based on their

morphology. When a graben was identified, we placed a point in the center.

3. Shadow measurements and displacement-length scaling calculations: We used recognized [**19**,**21**–**23**] shadow-length calculations to obtain depths of grabens. Using NAC frames with sufficient shadows, we measured shadow lengths and the lengths of faults bounding the grabens. We then plotted fault length vs average depth to compare our population of Hermean grabens with lunar and terrestrial analogues and to estimate the original depth of the grabens. The age of each graben was estimated based on the original graben depth and the assumed rate of infilling. We used infilling rates derived from lunar studies [**15**,**24**,**25**], and first estimated how long the grabens would take to infill using lunar rates of 5±3 cm per Ma and adjusted Hermean rates of 10±6 cm per Ma. We then were able to estimate total age of the grabens by calculating how long it would have taken for the graben to infill to its current depth having calculated its maximum depth from displacement-length scaling plot.

**Results:** Extensional grabens (**Fig 2** example) are found across the globe, on 294 individual shortening structures. The parent shortening structures are lobate scarps, wrinkle ridges and high relief ridges that cut all types of surface materials and vary in length (10s to 1000s km) and relief (10s meters to km) - **Fig 1**. Of the 727 grabens identified we classified them based on how confident we were of their existence, of which 190 were confidently identified. There is a concentration of extensional grabens on equatorial shortening structures, particularly those that strike radially to the Caloris impact basin. Based on shadow measurement calculations, displacement-length scaling estimates of the maximum depth of grabens and predicted rate of infilling for Mercury, we calculate that many of the grabens are only a few100 million years old most are likely less than a billion years old.

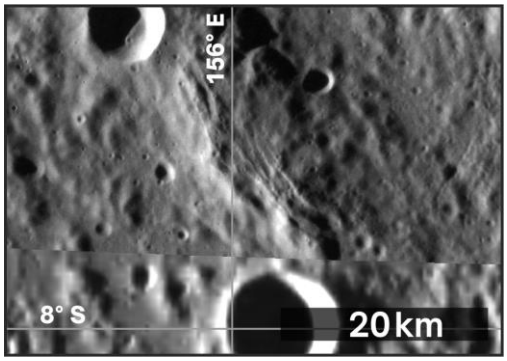


*Figure 2 Example of extensional grabens on Protea Rupes*

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