Recent tectonic activity on Mercury revealed by small thrust fault scarps

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SUPPLEMENTARY NOTES

S1. MERCURY LASER ALTIMETER PROFILES AND SHADOW MEASUREMENTS

Topography from the Mercury Laser Altimeter (MLA) has the highest spatial resolution in the higher latitudes of the northern hemisphere[1]. Only a few individual MLA tracks cross small scarps with sufficient shot spacing to sample the scarp topography. One such MLA track crosses a cluster of small, roughly north-south oriented scarps located on the floor of a ~25 km diameter crater in intercrater plains (Supplementary Fig. S1) (~32.3ºN, 42.0ºE). This cluster is located just north of two large lobate scarps with a similar orientation. The MLA topographic profile indicates one scarp in the cluster has ~19 m of relief (at the location of the profile), comparable to the relief estimated by shadow measurement.

The relief of the Mercury's small scarps is mostly determined using shadow measurement. Shadow lengths were measured directly from calibrated and geometrically corrected low altitude MDIS images. The error in the measured lengths of shadows is on the order of the pixel scale of the image because the true shadows cast by the scarps are expected to fall somewhere within the two pixels chosen as endpoints of the line defining the shadow length. This may lead to an overestimate of the true shadow length and thus the relief.

S2. DISPLACEMENT-LENGTH RELATIONS

The similarity between Mercury's small scarps and lunar small scarps is further demonstrated by the displacement-length relations of the associated faults. Faults populations formed in mechanically uniform rock demonstrate a linear relationship between fault length (L) and fault displacement (D) such that $D = \gamma L$, where γ is a constant determined by rock type and tectonic setting[2, 3]. This relationship is exhibited by planetary faults[4-6]. The values of γ for the lobate thrust fault scarp populations are determined by a linear fit to *D*-*L* data. The fault displacement is estimated by restoring the topography to a planar surface, approximated by $D = h/\sin\theta$ where h is the relief of the lobate scarp and θ is the dip of the fault plane[4, 7]. The γ of Mercury's large-scale lobate scarp faults is ~8.2×10^{-3} for a θ of 30º (*n*=12) (8) (Supplementary Fig. S2), estimated from measurements of scarp relief from MLA[1] and stereo-derived topography[9, 10], and is consistent with previous estimates of γ for the large scarps (11). The γ of lunar scarps, ~1.9×10^{-2} for a θ of 30º (*n*=36) (see 12) is also consistent with previous estimates[13] (Supplementary Fig. S2). It is estimated from relief measurements using Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Camera (NAC) stereo derived DEMs and Lunar Orbiter Laser Altimeter (LOLA) data[12]. The difference in γ between the two populations of thrust faults is likely due to the low number of small-scale scarps sampled on Mercury and possibly overestimates of the relief from inaccuracies in shadow measurements (Supplementary Note S1). Known influences on the value of γ are the tectonic setting and the rock type[2, 6]. The order of magnitude difference in γ between Mercury's small- and large-scale scarps (Supplementary Fig. S2) may be due to the difference in the properties of the deformed materials, particularly their strength[6].

Supplementary Note Fig. 1. Topography of a small scarp. A) A scarp in a cluster located on the floor of a crater (~32.3ºN, 42.0ºE) was crossed by a MLA track. Image frame numbers EN1044692210M and EN1044692212M. White dots along the ground track show the location of MLA shot points and the red dots show the elevation profile in Fig. 1B here plotted relative to the ground track. B) Topographic profile of a small scarp. Although the MLA track does not cross the small scarp at an optimum angle (orthogonal to the scarp face), the profile shows that the scarp has the typical morphology of lobate scarp, a relatively steep scarp face, and a more gently sloping back-scarp. The maximum relief of the scarp at the location of the profile is ~19 m. The origin of the plot corresponds to the elevation shown by the red dot in the middle of Fig. 2A. Elevations are referenced to a sphere of radius 2,440,000 m.

Supplementary Note Fig. S2. Log-log plot of maximum displacement as a function of fault length for lobate scarps on Mercury and the Moon. The γ values of the population of Mercury's small scarps, large-scale scarps, and lunar scarps were obtained by a linear fit to the *D*-*L* data with the intercept set to the origin[2].

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