EPSC Abstracts
Vol. 10, EPSC2015-927, 2015
European Planetary Science Congress 2015

Timing of activity of two fault systems on Mercury

V. Galluzzi (1,2), L. Guzzetta (3), L. Giacomini (4), L. Ferranti (5), M. Massironi (4) and P. Palumbo (1,2)
(1) Dipartimento di Scienze e Tecnologie, Università degli Studi di Napoli "Parthenope", Naples, Italy, (2) INAF, Istituto di Astrofisica e Planetologia Spaziali, Rome, Italy, (3) INAF, Osservatorio Astronomico di Capodimonte, Naples, Italy, (4) Dipartimento di Geoscienze, Università degli Studi di Padova, Padova, Italy, (5) DiSTAR, Università degli Studi di Napoli "Federico II" (valentina.galluzzi@iaps.inaf.it).

Abstract

Here we discuss about two fault systems found in the Victoria and Shakespeare quadrangles of Mercury. The two fault sets intersect each other and show probable evidence for two stages of deformation. The most prominent system is N-S oriented and encompasses several tens to hundreds of kilometers-long and easily recognizable fault segments. The other system strikes NE-SW and encompasses mostly degraded and short fault segments. The structural framework of the studied area and the morphological appearance of the faults suggest that the second system is older than the first one. We intend to apply the buffered crater counting technique on both systems to make a quantitative study of their timing of activity that could confirm the already clear morphological evidence.

1. Introduction

NASA MESSENGER mission confirmed the predominantly contractional deformation of Mercury's surface [1], [2]. The latest global structural mapping of Mercury revealed almost 6000 contractional structures [3]. The surface expression of most of these structures is represented by lobate scarps, which are steep scarps characterized by "a gently sloping back limb" [3] and are asymmetrical in cross-section [2]. They were described for the first time by [4] and interpreted as surface breaking thrusts. Usually, Mercury's thrusts are thought to be the expression of global contraction due to core solidification [4] or to a combination of global contraction, tidal despinning [5] and probably, mantle convection [6]. While several simulations take into consideration all of the three tectonic models, e.g. [7], [8], the timing and the actual development of these events is not yet clear. These faults often cut Calorian units, therefore their activity continued after the emplacement of these young terrains, e.g. [9]. A recent study of Hermean structures revealed the possibility that two stages of deformation might have occurred on a portion of the planet [10]. Thus, an accurate study of the interaction between the various Hermean fault systems is crucial to understand the timing of tectonic events. Our study aims at understanding the structural framework and timing of activity of two fault systems encompassed between the Victoria and Shakespeare quadrangles of Mercury.

2. Structural framework

The geological map of the Victoria quadrangle that was completed recently [11] revealed some new NE-SW oriented scarps, which are less prominent than lobate scarps and have a more degraded morphology that is often visible just from slight topographical changes. These structures continue to the west in the nearby Shakespeare quadrangle and they all seem to belong to the same system. On the other hand, the prominent Victoria Rupes, Endeavour Rupes and Antoniadi Dorsum lobate scarps (morphological *dorsa* are sometimes addressed to as high-relief ridges) form a N-S system that cuts the NE-SW system, which is interrupted in correspondence of a N-S fault-free topographic bulge [11], whose eastern margin was also interpreted as a fold-and-thrust belt by [3].

3. Timing analysis

The timing analysis of the two fault systems activity is done by means of morphological evidences, cross-cutting relationships and crater counting analysis. While the first two methods imply a qualitative description, the last method can provide quantitative evidence for different deformation stages.

3.1 Buffered crater counting

The "buffered crater counting" technique by [12], [13] has been hitherto used by [14] and [15] to assess fault

ages. It consists in counting craters unfaulted/undeformed by the nearby faults (in this work we consider fault buffer distance ≤ 1.5D, where D is the diameter of the crater), to get a cumulative size-frequency distribution (CSFD) that can be either compared to other CSFDs to get relative ages, or to production functions to get fault absolute ages. Buffered crater counting performed on the N-S system (Figure 1) already provided a relative age result that is younger than the smooth plains unit. Gathering data also from the NE-SW system will permit to compare the relative age of the two systems and verify the morphological evidence.

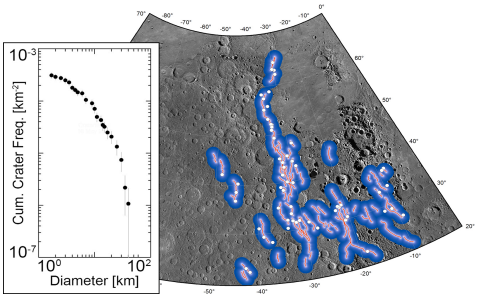

Figure 1. Example of a buffered crater count performed on the N-S fault system of the Victoria quadrangle (based on 61 counted craters). Basemap: MESSENGER MDIS 250 mpp mosaic (NASA/JHUAPL/CIW).

4. Summary and Conclusions

By analyzing the structural framework of the area between the Victoria and the Shakespeare quadrangles, two fault systems showing interesting cross-cutting relationship were found. The morphological evidence and the fault segments distribution seem to suggest that the NE-SW system is older than the N-S system [11]. This also seems to suggest that two stages of deformation acted on this area as also argued by [10] on another location of Mercury. The buffered crater counting method applied on both systems will permit to better estimate their relative age, thus getting us closer to understanding the evolution of Mercury.

Acknowledgements

This research was supported by the Italian Space Agency (ASI) within the SIMBIOSYS project (ASI-INAF agreement no. I/022/10/0).

References

[1] Watters, T.R. Solomon, S.C., Robinson, M.S. et al.: The tectonics of Mercury: The view after MESSENGER's first flyby, Earth and Planetary Science Letters, Vol. 285, pp. 283–296, 2009.

[2] Byrne, P.K., Klimczak, C., Şengör, A.C. et al.: Mercury's global contraction much greater than earlier estimates, Nature Geoscience, Vol. 7, pp. 301–307, 2014.

[3] Watters, T.R. & Nimmo, F.: The tectonics of Mercury, in Watters, T. R. & Schultz, R. A. (eds), Planetary tectonics, Cambridge University Press, 2010.

[4] Strom, R.G., Trask, N.J. and Guest, J.E.: Tectonism and volcanism on Mercury. Journal of Geophysical Research, Vol. 80, pp. 2478–2507, 1975.

[5] Melosh, H.J. & Dzurisin, D.: Mercurian global tectonics: A consequence of tidal despinning?, Icarus, Vol. 35, pp. 227–236, 1978.

[6] King, J.S.: Pattern of lobate scarps on Mercury's surface reproduced by a model of mantle convection, Nature Geoscience, Vol. 1, pp. 229–232, 2008.

[7] Matsuyama, I. & Nimmo, F.: Gravity and tectonic patterns of Mercury: Effect of tidal deformation, spin‐orbit resonance, nonzero eccentricity, despinning, and reorientation, Journal of Geophysical Research: Planets (1991‐2012), Vol. 114, 2010.

[8] Klimczak, C., Byrne, P.K. and Solomon, S.C.: A rock-mechanical assessment of Mercury's global tectonic fabric, Earth and Planetary Science Letters, Vol. 416, pp. 82–90, 2015.

[9] Watters, T.R., Robinson, M.S., Bina, C.R. et al.: Thrust faults and the global contraction of Mercury, Geophysical Research Letters, 31, L04701, 2004.

[10] López, V., Ruiz, J. and Vázquez, A.: Evidence for two stages of compressive deformation in a buried basin of Mercury, Icarus, Vol. 254, pp. 18–23, 2015.

[11] Galluzzi V.: Structural analysis of the Victoria quadrangle (H2) of Mercury based on NASA MESSENGER data, PhD thesis, 2015.

[12] Tanaka, K.L.: A new time-saving crater-count technique, with application to narrow features, in: Reports of Planetary Geology Program, NASA TM-85127, 1982.

[13] Fassett, C.I. & Head III, J.W.: Valley network-fed, open-basin lakes on Mars: Distribution and implications for Noachian surface and subsurface hydrology, Icarus, Vol. 198, pp. 37–56, 2008.

[14] Giacomini, L., Massironi, M., Marchi, S. et al.: Age dating of an extensive thrust system on Mercury: implications for the planet's thermal evolution, Geological Society, London, Special Publications, Vol. 401, pp. 291–311, 2015.

[15] Kneissel, T., Michael, G.G., Platz, T. et al.: Age determination of linear surface features using the Buffered Crater Counting approach – Case studies of the Sirenum and Fortuna Fossae graben systems on Mars, Icarus, Vol 250, pp. 284–394, 2015.