EPSC Abstracts
Vol. 10, EPSC2015-776, 2015
European Planetary Science Congress 2015

Terrestrial and extraterrestrial landslide size statistics

M. T. Brunetti (1), Z. Xiao (2,3), G. Komatsu (4), S. Peruccacci (1) and F. Guzzetti (1)
(1) Research Institute for Geo-Hydrological Protection – Italian National Research Council, Perugia, Italy (Maria.Teresa.Brunetti@irpi.cnr.it/fax:+39-075-5014420), (2) Planetary Science Institute, China University of Geosciences, Hubei, P. R. China, (3) Centre for Earth Evolution and Dynamic, University of Oslo, Norway, (4) International Research School of Planetary Sciences, Pescara, Italy

Abstract

We present the size statistics of landslides on Earth, Mars, the Moon and Mercury. We used two existing landslide inventories for New Mexico (USA) and for Valles Marineris, Mars, and two new inventories of lunar and Mercurian landslides. Failures on the Moon and Mercury were detected and mapped along the internal walls of impact craters. The statistical distributions of the extraterrestrial landslide area were exploited to compare the results with similar distributions obtained for terrestrial landslides.

1. Introduction

Landslides play an important role in shaping the surface of the Earth and of other solid bodies, like Mars, the Moon, and Mercury. In the last decades, planetary exploration missions have released large amount of high-resolution images, which enable to detect and map morphologic structures on planetary surfaces in great detail. On Mars, large landslides have been observed mainly along the slopes of Valles Marineris, e.g. [1-2]. Numerous landslides of various scales have been observed on the Moon, e.g. [3]. On Mercury, some ejecta flows exhibit morphological similarities with mass wasting deposits on planetary surfaces. Comparison of landslide characteristics, e.g. the landslide types and sizes (area, volume, fall height, length) on different planetary bodies may help in understanding, e.g., the effect of the surface gravity on failure initiation and propagation.

2. Methodology

To compare the terrestrial and extraterrestrial landslide size statistics, we exploited a geomorphological inventory of 894 deep-seated landslides of the slide and complex types mapped in New Mexico, USA [4] and three inventories of extraterrestrial landslides. On Mars, we focused on a study area of 10^5 km^2 in Tithonium and Ius Chasmata, Valles Marineris where 189 landslides, including rock slides, complex landslides, debris flow-like failures, and rock avalanches, were previously identified and mapped [2]. Figure 1 shows an example of a rock slide on Mars.

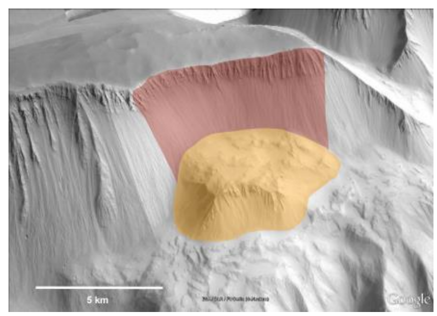

Figure 1: A rock slide in Valles Marineris, Mars. The failure scarp is in brown and the deposit is in amber.

To recognize and map landslides on the Moon and Mercury, we adopted the same visual criteria commonly used by geomorphologists to recognize terrestrial failures. On the Moon and Mercury, we focused on the large slope failures along the internal walls of impact craters. In particular, we selected and mapped landslides in simple craters, in order to deal with mass movements driven by the surface gravity and not resulting from the impact processes. For the Moon, we visually analyzed images acquired at 100 m/pixel resolution by the Wide Angle Camera onboard the Lunar Reconnaissance Orbiter Camera. For Mercury, we examined images at an average resolution of 250 m/pixel obtained by the Wide Angle Camera onboard the MESSENGER spacecraft.

3. Results

In impact craters on the Moon and Mercury, we obtained two inventories of 60 landslides mapped in 35 craters on the Moon, and 58 landslides mapped in 38 craters on Mercury. Figure 2 portrays two examples of rock slides on the Moon (a) and on Mercury (b).

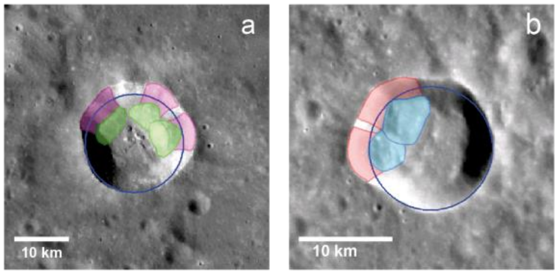

Figure 2: Rock slides on the Moon (a), and Mercury (b). Landslide scarps are in purple (a) and red (b); deposits are in green (a) and light blue (b).

Using the planimetric area, A_L, of the mapped failures we calculated the probability density distribution of the landslide area for the Moon and Mercury. Figure 3 displays the comparison between the probability density distribution, $p(A_L)$, of the landslide area, A_L, for terrestrial failures and for failures on Mars, the Moon, and Mercury.

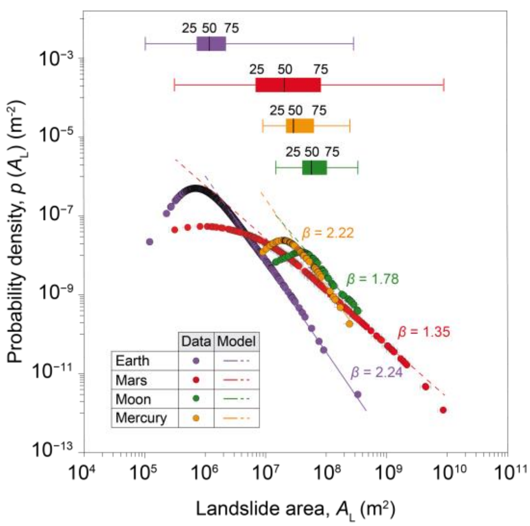

Figure 3: Probability distributions of landslide area on Earth (purple), Mars (red), the Moon (green) and Mercury (orange). Color lines show corresponding best fit models of the distribution tails. Box plots show statistics of A_L for all data sets.

Analysis of the distributions indicates that extraterrestrial landslides are larger than subaerial terrestrial landslides. On Mars, $p(A_L)$ is flatter than on other bodies. As a result, on Mars the abundance of very large landslides ($A_L>10^7 m^2$), compared to small and medium area failures, is higher than on Earth. Lunar landslides are on average larger than failures on Mercury. We hypothesize that the stronger surface gravity of Mercury causes landslides occurring at smaller scales.

References

[1] Quantin, C., Allemand, P., and Delacourt, C.: Morphology and geometry of Valles Marineris landslides. Planet. Space Sci. 52 (11), 1011-1022, 2004.

[2] Brunetti, M.T., Guzzetti, F., Cardinali, M., Fiorucci, F., Santangelo, M., Mancinelli, P., Komatsu, G., and Borselli, L.: Analysis of a new geomorphological inventory of landslides in Valles Marineris, Mars. Earth Planet. Sci. Lett. 405, 156-168, 2014.

[3] Xiao, Z., Zeng, Z., Ding, N., and Molaro, J.:. Mass wasting features on the Moon–how active is the lunar surface? Earth Planet. Sci. Lett. 376, 1-11, 2013.

[4] Cardinali, M., Guzzetti, F., and Brabb, E.E.: Preliminary map showing landslide de-posits and related features in New Mexico. U.S. Geological Survey Open File Report 90/293, 4 sheets, scale 1:500,000, 1990.