Fluctuation of recent large impact craters rate on Mars from automatic crater detection

Anthony Lagain¹, Misha Kreslavsky², Gretchen Benedix¹, David Baratoux³, Phil Bland¹, Martin Towner¹, Jonathan Paxman⁴, Sylvain Bouley². Chris Norman¹, Seamus Anderson¹, Konstantinos Servis¹, Elena Samson¹, Kevin Chai⁷, and Shiv Meka⁷

¹Space Science and Technology Centre, School of Earth and Planetary Sciences, Curtin University, Perth, WA, Australia (anthony.lagain@curtin.edu.au)
²Earth and Planetary Sciences, University of California, Santa Cruz, CA, USA
³French Research Institute for Sustainable Development, Toulouse, France
⁴School of Civil and Mechanical Engineering, Curtin University, Perth, WA, Australia
⁵GEOPS laboratory, Paris-Saclay University, France
⁶CSIRO - Pawsey Supercomputing Centre, Kensington WA, Australia
⁷Curtin Institution of Computation, Curtin University, Perth, WA, Australia

Knowledge of collision rates through time and space is essential because meteoritic impact crater counting is the only way to determine the ages of surface geological units and processes on the solid bodies of our Solar System. All chronology models assume a constant size distribution of impactors and an exponential decay of the impact flux between 4 Ga and 2.5 Ga before the present followed by a constant rate over the last 2.5 Ga. These two assumptions are challenged by recent evidence for an increase of the impact flux on the Moon and the Earth and probably on Mars associated with a decoupling between the flux of small and large impactors over the last billion years. Here, using the results of an automatic crater detection algorithm, we investigate the evolution of the rate of formation of large impact craters (Dc ≥ 20km) on Mars and thus infer the evolution of the flux of large impactors (Di > 5km) from the size-frequency distribution of small craters superposed to the ejecta blankets of large ones.

The dating of large impact craters on Mars is limited by several factors such as the degradation of ejecta blankets and the retention rate of small craters superposed to their ejecta. We therefore focused on craters ≥20km in diameter exhibiting an ejecta blanket according to the crater database and located on a latitudinal band between ±35°. We then selected those whom their ejecta are not affected by volcanic/tectonic processes or by the formation of another large nearby impact crater. The final set includes 590 impact craters.

If one can argue the impact flux cannot be fully recorded for the last 4Ga due to resurfacing processes erasing progressively the ejecta blanket and large craters themselves, Hesperian and Noachian terrains within the 35° latitudinal band should nevertheless have retained all D≥20km craters over a portion of the Amazonian period. The CSFD of craters younger than 600Ma (113 craters) superposed to these terrains is consistent with the 600Ma isochron, supporting the fact
that the entire population of craters ≥20km formed over the last 600 million years on this portion of the Martian surface has been counted completely. We therefore focused on the analysis of the impact rate evolution over this range of time from this crater sub-sample.

The formation of large impact craters is not homogeneously distributed over the time range investigated here. Our data suggest an inconsistency between the flux used to date each crater and the rate inferred from these datings, thus implying that the small and large body impact fluxes are decoupled from one another. We note also sharp peaks centered around 480, 280 and 100Ma. Preliminary statistical test show that 280Ma peak is marginally significant whereas the two others are too small to be statistically significant. This pattern would be consistent with other independent arguments for increased rate with similar intensity and timing on the Moon and Mars for which the causes are probably collisions and potentially formation of asteroid families within the main asteroid belt.