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# A reassessment of impact crater degradation by climatic processes on Early Mars

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## 1. Introduction

Crater degradation on Mars is a key to understand erosion through time. Strongly eroded craters in the highlands are interpreted to be the result of enhanced erosion rate during the Noachian epoch [1]. While fluvial valleys climatic meaning and duration are still difficult to define (strongly warmer climate or episodic activity under slightly warmer climate), the enhanced Noachian craters degradation favors a prolonged erosion with high erosion rates. Most data used for classification and understanding of these craters were done using Viking data by photogrammetry. We choose here to use MOLA data in two Noachian regions to study the evolution of this degradation in time: North Hellas and Southern Margaritifer Terra.

## 2. Results

Craters larger than 20 km in diameter were studied. The crater population ( $N > 100$ ) was classified in three main groups from image analysis: (1) Degraded craters for which neither ejecta nor central peak was visible at any resolution, with rims being eroded by fluvial valleys; (2) Partially degraded craters, for which ejecta and central peak were still visible, but fluvial landforms were observed on rims, at least partially, and (3) Fresh impact craters, for which ejecta and central peak were obvious, and for which no sign of fluvial landform was present. Compared to previous work by Craddock et al. [1], we have simplified the classification of the initial 5 classes used in only 3. Of interest is the observation that all craters of the second class showed not only fluvial valleys, but also alluvial fans as defined in the study by Moore and Howard [2].

Quantitative measurements of the crater depths, diameters and slopes were achieved to distinguish modifications. Degraded craters (class 1) have a large variety of depth/diameter ratio, with a lower ratio than the two other classes resulting from the enhanced degradation. The class 2 shows very similar ratios than the class 3, both in terms of depth/diameter ratio and slopes. This demonstrates that class 2 does not represent a class of high degradation, but a class of gently degraded craters which erosion was much lower than class 1. Class 2 therefore corresponds to relatively fresh craters only slightly modified by fluvial erosion.

## 3. Interpretation

These results are surprising because craters of class 2 display large alluvial fans and were interpreted by [2] as being related to a climatic optimum at the Noachian-Hesperian boundary. Our results show that the intensity of erosion and degradation of these craters is not consistent with such an optimum questioning the origin of this fluvial activity. Assuming that these craters formed later than those of the class 1 (that are more degraded with lower depth/diameter ratios), our results show that the alluvial fans observed formed either (i) by a late climatic episode in the Hesperian period, subsequent to the Late Noachian climatic optimum inside a generally cold period, or (2) by processes related to the crater formation itself, as proposed by different authors [e.g. 3, 4].

In addition, the lack of similar large alluvial fans on class 1 needs to be understood. Did fans also exist on class 1 but were buried by subsequent sediments of volcanic infillings? Or did previous degradation involved different processes leading to different morphology with flatter fans? The understanding of

the degradation of these craters is of main importance for understanding the early climate, because craters recorded all modification since their formation, whereas other landforms such as fluvial valleys correspond to the last visible episodes of erosion.

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