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A Chronology Of Mars Climatic Evolution From Impact Crater Degradation

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Impact crater degradation provides a powerful tool to analyze past Martian hydrological evolution. Degraded craters are one of the main lines of evidence for a warmer climate on early Mars. Global altimetry and recent high resolution imagery enable us to revisit previous studies. In particular it allowed us to identify preserved impact ejecta, which is strong evidence for limited degradation, and fluvial landforms on rims. These details were particularly pertinent in the case of the craters with alluvial fans. We distinguished only three classes, using two main parameters: the presence of preserved ejecta and of fluvial activity: Type I: Craters with fluvial erosion on walls and rim but lacking an ejecta blanket. Type II: Craters with fluvial erosion on walls and rim and a preserved ejecta blanket. Type III: Fresh craters lacking any fluvial erosion on rim with a preserved ejecta blanket. Type II craters are those containing alluvial fans. A total of 283 craters in two main regions were able to be classified according to our scheme. We have extracted parameters such as diameter, depth, slope and concavity. Type III, which are the youngest craters have the deepest depths for a given diameter, and type I, the shallowest depths. Type II craters lay in-between these two other types. The fact that type II craters lay between types I and III, shows that this crater type is intermediate in the degradation series and therefore implies that this crater type is inter-mediate in age. The chronology of all the craters in this region can be performed using classical isochrons. All the craters together gives an isochron at 4.00$\pm$0.03 Gy, which corresponds to the age of the basement. The transition between type I and type II craters occurs at 3.70$\pm$0.06 Gy, an age corresponding to the middle of the Early Hesperian period in this model age system. This age pinpoints the period during which the strong fluvial degradation of Early Mars stopped. The transition between type II and type III is dated at $\sim$3.32 +0.12/-0.34 Gy, thus at the beginning of the Early Amazonian in this age system. Our chronology shows that type II craters which contain alluvial fans formed from the Early Hesperian to earliest Amazonian epochs that are known to have been significantly colder than the Noachian period. It appears from our study that important craters such as Holden and Gale crater follows the type of depth/diameter relationship and style of type II craters formed during this late period. While climatic effects are still possible at that time, impact events can create significant warming, which can also cause the melting of subsurface ice or surface snow. Lastly, a recent study focused on 250-800-km impact craters and on Hesperian volcanoes showed that the dynamo stopped likely between 3.75 and 3.79 Gy, well after the Hellas impact (Langlais et al., DPS/EPSC, 2011-773). This event may have caused a sudden climatic shift, which provoked the sharp change in crater degradation conditions that we have detected.