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The geologic evolution of Mars: Episodicity of resurfacing events and ages from cratering analysis of image data and correlation with radiometric ages of martian meteorites

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In early attempts of understanding the time-stratigraphic relationships on the martian surface by crater counting techniques and principles of stratigraphic superposition, most of the geological units and constructs came out as being rather old, in the range of billions of years. On the other hand, most of the ages of the martian meteorites cluster at relatively young values of around 175 m.y., 300-600 m.y. and approx. 1.3 Ga, whereas very few old ages $>$3 Ga had been found. The early cratering age data were based on post-Viking image data analysis. With the new data from MGS (MOC), MEX (HRSC), and Mars Odyssey (THEMIS), it has become clear by now that the apparent discrepancy between the two age sets and the predominance of old ages was a selection effect due to the limited Viking resolution showing predominantly large, old features. Ages as young as a few 100s, a few tens or even a few million years have been determined since on the basis of the new high-res imagery with spatial resolutions in the meter to tens-of-meters range. It has become clear therefore by now, that there is no basic discrepancy with respect to the age ranges and occurrence of age groups per se. We reported on first preliminary results from investigation of a

combination of HRSC and MOC imagery previously where we believed to have seen peaks of activity temporally coinciding with martian meteorite age groups. We have now been able to investigate a much higher number of areas and have in particular mapped out and analyzed for their geologic evolution and cratering ages two large outflow channel areas, Echus Chasma/Kasei Valles and Mangala Valles. In both areas we have found multistage geological histories with mixed volcanic, fluvial, glacial, and hydrothermal activity. There is a striking appearance of peaking of the geological activity or episodicity of resurfacing at certain times: approx. 3.5 Ga, 1 to 1.5 Ga, 300 to 600 m.y., approx. 200 m.y. ago, respectively. Even more striking is that within relatively narrow limits, the cratering ages of the different age groups fall together with the age groups of martian meteorites. The martian meteorite ages reflect both igneous events and aqueous alteration events. So do the cratering ages. There is a remarkable paucity of age occurrences in the 2-3 Ga age range in the cratering data. This corresponds to a paucity of meteorite ages in the same, even somewhat more extended age range. This appears to be a hint to either lower geologic activity in this time frame, or, more likely, the covering up of more ancient activity by subsequent events $<$2 Ga ago, with the exception of the residues from the time $>$3 Ga ago (the peak at approx. 3.5 Ga) when the martian surface was thoroughly shaped at a very high level of activity by gigantic volcanic, fluvial, and glacial events which could not be completely erased by later events.