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The Evolutionary History of Martian Volcanic Constructs seen from Mars Express HRSC

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Introduction: During the first year of the ESA Mars Express mission in orbit, the High Resolution Stereo Camera, a multiple line scanner instrument, is acquiring high-resolution colour and stereo images of the surface of Mars [1]. Resolution down to 10 meters per pixel coupled with large areal extent (swaths typically 60-100 km wide and thousands of km long) means that small details can be placed in a much broader context than was previously possible. All major volcanic constructs including many Paterae and Tholi have been covered in the first period of the mission. The ability to image in colour and stereo simultaneously gives us new opportunity to better characterize most of the volcanoes in the Tharsis and Elysium region and some highland volcanoes geomorphologically and chrono-stratigraphically. We have remapped major parts of the volcanic shields and calderas on the basis of the high-resolution (as good as 10 m/pixel) HRSC imagery in colour and stereo and in combination with nested MOC imagery [2] and the Super Resolution Channel (SRC) (as good as 2.5 m/pixel) of the HRSC.

Method: To determine absolute ages on Mars we measure the crater size frequency distribution for a geomorphologically mapped unit and fit the crater production function [3,4] to the data set, extract a size-frequency value for craters of one kilometer and larger, and apply the Hartmann/Neukum chronology model [5] for the derivation of an absolute age.

Large volcanic constructs: Hecates and Albor Tholus were observed in Orbit 32. Both belong to the Elysium region, one of the smaller volcanic bulges in the northern lowlands. The caldera morphologies indicate step-wise volcanic activity and the ages derived from crater size-frequency measurements yield a period of activity over 2 billion

years for Albor Tholus. For Hecates Tholus the recorded ages range between 1 billion and 100 million years (see also [6]). The three Tharsis Montes, belonging to the largest volcanic region of Mars: Arsia Mons, covered in Orbit 263, is the southernmost construct of that unit. It is characterized by a single caldera floor of an age of about 130 Ma (see also [6]). Small volcanic domes in the Arsia Mons caldera, following the major fault direction of the Tharsis Montes group, hint to possibly still active volcanism. Pavonis Mons was covered in Orbit 891 (and Orbit 902) and is the middle one with two caldera levels (activity over the last half billion years). Ascraeus Mons was covered in Orbit 68 (and Orbit 16) and is the northernmost of the volcano triplet. Its caldera is represented by a number of floor levels indicating again repeated eruption activity in the last one billion years (see also [6]). Possibly some of the calderas have been formed much earlier in the lifetime of the volcano. The caldera of the largest Martian volcano Olympus Mons was covered in Orbit 37. Again the caldera floor level and morphology indicate repeated eruption activity. The age measurements yield an activity phase between 100 and 200 million years ago (see also [6]). Crater frequencies measured on the different caldera floors indicate ages, which slightly deviate from the morphologically expected time-stratigraphic derived volcanic sequence for the formation of the calderas. A detailed study of the caldera morphology show for the larger caldera floors tectonic and volcanic resurfacing affecting the age results.

Highland volcanoes, Paterae and Tholi: The highland volcanoes (Tyrrhena, Hadriaca, Amphitritis and Apollinaris Paterae) were imaged in a number of early orbits and crater counts have been performed. The image resolution covering these volcanoes range between 10 and 30 m/pixel. Not only the calderas but also flanks and flows are studied. Most Paterae and Tholi in the Tharsis region are covered by two different image resolutions. Preliminary measurements of the crater size frequencies indicate, that their active period ended in the early Martian history at about 3.7 Ga ago. Crater counts on high resolution imagery are in progress and will be discussed in terms of later resurfacing in the small volcanoes vicinity to better understand the general evolution of the Tharsis region volcanism. These results will be discussed in comparison with earlier age measurements (e.g.[7]).

Results: Crater size-frequency measurements confirm that the edifices have been constructed over billions of years [7] and are characterized by episodically repeated phases of activity continuing almost to the present [6]. The youngest ages determined by the crater size-frequency measurements are about 2 Ma suggesting that the volcanoes are potentially still active today. A number of caldera floor ages cluster around 150 Ma indicating a relatively recent peak activity period and practically coinciding in age with radiometrically measured crystallization ages of a group of basaltic meteorites from Mars (SNC meteorites [8]). Most of the smaller volcanoes in the Tharsis

region have been active in the early Martian geological history, similar to the highland volcanoes. The long activity of Martian volcanoes implies a correspondingly long lifetime of the feeding source especially in the Tharsis region, indicating a long and stable dynamical regime in the planet s interior.

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