RECENT GEOLOGICAL AND HYDROLOGICAL ACTIVITY IN AMAZONIS AND ELYSIUM BASINS AND THEIR LINK, MARTE VALLIS (AME): PRIME TARGET FOR FUTURE RECONNAISSANCE.

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Introduction: A new global impact crater data base [1-2] uniquely highlights a geologically and hydrologically youthful region of Mars (Figs. 1-2): parts of Amazonis and Elysium basins and their link, Marte Vallis (hereafter referred to as AME). Coupled with previous works [3,4], the information presented here, including a youthful shield volcano and pristine lavas marked by a paucity of relatively small (~few-km-diameter) superposed impact craters and modified by faults and fractures and valleys point to a geologically and hydrologically active Mars (Fig. 3). For example, there are only two superposed impact craters with pristine ejecta blankets on the floor of Marte Vallis recently resurfaced by volcanic and/or hydrologic activity. In addition to the youthful magma, water, and tectonic interactions presented here, Icelandic-like activity [5], possible ice enrichment and related aqueous phenomena [6-7], and Mars Odyssey Gamma Ray Spectrometer-based elevated chlorine [8-11] collectively make AME a significant target for future reconnaissance, including testing the hypotheses of whether Mars is geologically, hydrologically, and biologically active.

Geologic and Physiographic Setting: AME is central to the Tharsis/Elysium corridor defined by [3] (Fig. 1), which includes parts of the Tharsis and Elysium magmatic complexes and the intervening region [3]. AME includes parts of the large basins of Amazonis and Elysium Planitiae, which may have been occupied by water bodies [12-13], and the outflow channel that links the two basins, Marte Vallis, interpreted to be a spillway [13]. The basins and Marte Vallis have been mapped and interpreted to be blanketed by stratigraphically young lava flows [14], perhaps mantled by fine-grained materials. The relatively pristine lava flows may have originated from Tharsis and Elyisium, small shield volcanoes (Fig. 3A), and fissures such as those related to basement structures in the martian crust. The northwest-trending Cerebus Fossae is a prime example of a fissure [14-15].

The stratigraphic record specifically in AME is dominated by magma, basement structural control (*e.g.*, joints, fractures, and faults), and liquid water and/or ice interactions possibly linked to the evolution of Tharsis [16-17] and Elysium [14-15]. These major magmatic complexes are prominent surface expressions related to the concentrated release of internal heat energy during the stagnant-lid phase of Mars' evolution [18]. Incipient development of Tharsis is recorded as far back as the Noachian, whereas Elysium began to form during the Early Hesperian. Episodic activity continued for both complexes well into the Late Amazonian [16,19-20], and the activity is recent enough that it is reasonable to expect that it may persist at present, especially highlighted at AME.

Impact Crater Perspective: All impact craters [1] were extracted from stratigraphically young parts of AME (Fig. 1-2), partly defined through the detailed stratigraphic mapping of [14] with our own refinements. Cumulative size-frequency diagrams (SFDs) were created [21] and isochrons were fit from both the Hartmann [4] and Neukum [22] chronologies. These provide minimum ages of the basement of the three mapped regions: Amazonis basin being ~2.2-3.1 Ga (min: [4], max: [22]), Marte Vallis 3.2-3.6 Ga, and Elysium basin ~3.7 Ga (higher-frequency curves in Fig. 2). Variations in the differences in the model crater-retention ages are due to fitting different parts of the SFDs where there are different levels of agreement between the two chronology systems.

All impact craters in AME with diameters $D \geq 1$ km were manually examined to identify only those superposed on the most recent resurfaced terrains: those impact craters that display pristine rims and ejecta blankets, and well-defined bowl-shaped basins with little to no infill that have no visible evidence of volcanic, fluvial, and tectonic resurfacing. Albedo differences, which mark inverted stratigraphy such as dark-albedo ejecta deposits onlapping light-albedo rock units harvested from the subsurface, was also useful in identifying superposed impact craters.

The superposed impact craters were additionally verified through ConTeXt camera images if there was coverage [23]. After classification, additional SFDs were created (lower-frequency curves in Fig. 2) and age-dated. These were significantly younger, and again it should be emphasized that only two superposed craters $D \geq 1$ km were identified in Marte Vallis (an area of 99,308 km^2) (Fig. 1). Based on the isochron ages, the most recent activity at Amazonis basin dates to 90-105 Ma, Marte Vallis 230-470 Ma, and Elysium basin 83-95 Ma. When including fit uncertainties, the ranges are 65-125 Ma, 85-862 Ma, and 55-135 Ma, respectively (large uncertainties are due to only two craters in Marte Vallis). The age overlap and the direction of fluvial activity (Fig. 3B) collectively suggest that liquid water could have partly filled Elysium basin, flowed through Marte Vallis, and emptied into Amazonis basin as recently as ~100 million years ago, which corresponds with some of the latest stages of major volcanism on the planet [24]. These ages are comparable with results from [4] who found Marte Vallis aging ~30-300 Ma.

Summary: The following queries might be addressed through international reconnaissance missions to AME, which would include instrument suites with optimal geologic, geochemical, geophysical (including seismic), environmental, and biological capabilities, including whether Mars: (1) is geologically and hydrologically active, (2) contains salty groundwater and magma at relatively shallow depths, (3) has sustained elevated heat flow, (4) records seismic activity, and (5) comprises fossilized and/or extant life. Certainly, AME and its various landforms, which include geologically young drainage networks and a shield volcano with collapse and vent-release features (Fig. 3), can be readily and feasibly assessed through landing and roving agents within current engineering constraints. This is a golden age of Mars exploration and discovery, and AME as a prime target in the not-too-distant future could answer many long-standing questions about the red planet.

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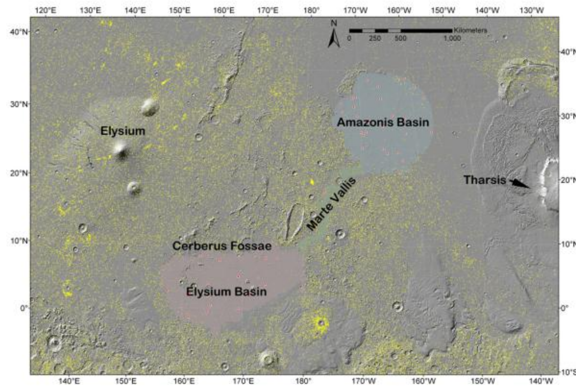

Figure 1: Large part of the Tharsis-Elysium corridor [3] with the crater database [1, 2] overlaid on MOLA shaded relief (yellow dots are mapped impact craters, red dots mark superposed craters on AME). Mapped region colors correspond to regions identified in Fig. 2.

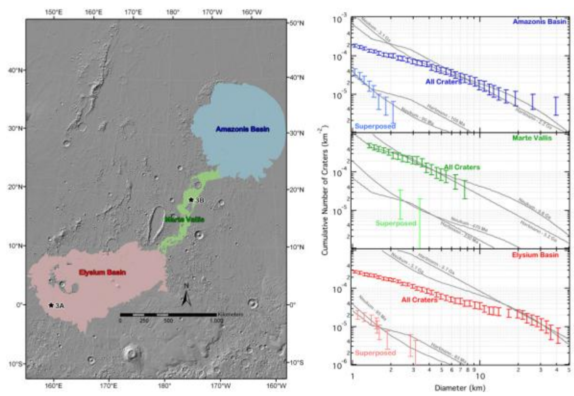

Figure 2: Left– Mapping regions separated into Amazonis Basin, Marte Vallis, and Elysium Basin. Labeled stars refer to frames in Fig. 3. Right– Same-scale cumulative size-frequency distributions showing all crater counts (darker colors, higher density data) and superposed crater counts (lighter colors, lower density data). Grey lines indicate best-fit isochrons from the two main systems in use [4, 23] and are labeled with ages.

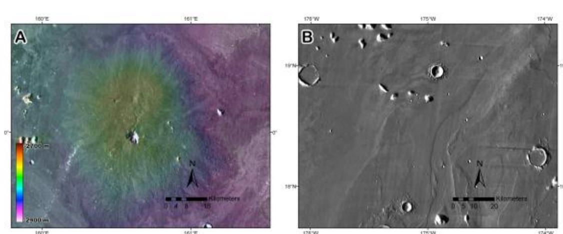

Figure 3: A. Youthful, low-angle shield volcano with summit caldera in Elysium basin (160°E, 0°N) on the western margin of AME (combined MOLA and THEMIS). B. Geologically recent resurfacing in Marte Vallis, including drainage networks (channel dissection and sheet wash) and modified craters, which includes streamlined bedforms indicating NE flow towards Amazonis basin (THEMIS mosaics).