MARS CHANGING ENVIRONMENT, HABITABILITY, AND PRIME TARGETS. J.M. Dohm[1], H. Miyamoto[1], A.G. Fairén[2,3], V.R. Baker[4], M., Spagnuolo[5], R.C. Anderson[6], G. Komatsu[7], W. Fink[8], W.C. Mahaney[9], D. Schulze-Makuch[10], T.M. Hare[11], M.R. El-Maarry[12], J.-P. Williams[13], C.E. Viviano-Beck[14], S. Karunatillake[15], T. Niihara[1], S. Maruyama[16], [1]The Univ. Mus., The Univ. of Tokyo, Tokyo, Japan (jmd@um.u-tokyo.ac.jp), [2]CAB, Madrid, Spain, [3]Dept. Astron., Cornell Univ., Ithaca, USA, [4]Dept. of HWR, The Univ. of Arizona, Tucson, USA, [5]Inst. de Estudios Andino Don Pablo Groeber, Buenos Aires, Argentina, [6]JPL, Caltech, Pasadena, USA, [7]Int. Res. School of Planet. Sci., Univ. d'Annunzio, Pescara, Italy, [8]Coll. of Eng., Dept. Elec. and Comp. Eng., The Univ. of Ariz., Tucson, USA, [9]Quaternary Surveys, Thornhill, Canada, [10]Cent. Astron. and Astrophys., Tech. Univ., Berlin, Germany, [11]USGS, Flagstaff, USA, [12]Physikalisches Institut, Bern Universität, Berne, Switzerland, [13]Dept. of Earth, Planet., Sci., Univ. of Cal., Los Angeles, USA, [14]Appl. Phys. Lab., Johns Hopkins Univ., Laurel, USA, [15]Geol. & Geophys. Louisiana State University, Baton Rouge, USA [16]Tokyo Tech., Tokyo, Japan

Before the ~4.0 Ga Hellas impact [1], a hypothesized dynamic Mars included a powerful dynamo/magnetosphere and a global hydrological cycle with an ocean, and plate tectonism [2]. A prime sign of this is a systematic, spatial arrangement of landforms in a pattern strikingly similar to that of the western United States [3]. The latter resulted from plate tectonism, including subduction of the dense, mafic Farallon Plate beneath the less dense, felsic North American Plate. The proposed Claritas subduction region [3] includes pre-Tharsis mountain building and basin formation, activities which may have contributed to the Tharsis Superplume [4]. Inferring from Earth history, an ocean with a sufficient water column (i.e., depth above the oceanic ridges) was necessary for plate tectonism to operate [5]. This points to a Hadean-age-equivalent (HAE) Martian ocean, and also a relatively dense atmosphere, which may have interacted with a felsic-enriched supercontinent (i.e., cratered highlands [6]) through Sun-driven hydrological cycling [7].

Martian planetary differentiation [2] and the initiation of a primordial ocean [8] may have occurred near the onset of Mars geological history (~4.4 Ga). With the dynamo terminating prior to 4.0 Ga and plate tectonism possibly continuing until ~3.83 Ga [9] (for estimated absolute ages correlated with time-stratigraphy see [10]). Examples of prime targets to sample for potential HAE rock/environmental records, using current lander mission designs, are Phlegra Montes and portions of Terra Sirenum [11], where alluvial fan materials and possible paleosols [12] would provide samples from basement complex materials. Moreover, landing sites in both these regions could also yield younger geological records, such as ~3.85 Ga to 1.03 Ga marine deposits and ~<.33 Ga Elysium lava flow materials that occur near Phlegra Montes.

At the time of the Hellas impact [1], major changes in global planetary conditions of Mars included cessation of a dynamo and magnetosphere at about 4.0 Ga [2]. In addition, plate tectonism was slowing down, the atmosphere was thinning, and the subaerial environment was being increasingly exposed to enhanced solar and cosmic bombardment [2]. Even so, within about 70 myr after the Hellas impact, the Argyre event generated a lake sufficient in extent to have sourced the Uzboi Vallis [13] that conveyed water through various channels and basins to the northern plains ocean [14]. Directly following the Argyre impact, surface water bodies on Mars included a northern plains ocean [14], the Argyre [13] and Hellas [15] megalakes, and smaller crater lakes [16]. The Argyre basin records evidence of long-term water enrichment and energy conditions, including impact-derived basement structures that acted as conduits for the migration of heat energy and volatiles. The occurrence of probable open system pingos downslope of structurally-controlled gullies [17] suggest that this activity may persist, making these features of particular astrobiologic interest but requiring nontraditional modes of reconnaissance [18,19].

Valles Marineris has recorded long-term, magmatic-tectonic activity including hydrothermal activity since at least ~3.85 Ga [20]. Like Argyre, Valles Marineris has served as a major catchment for atmospheric moisture in the form of transient precipitation [21] and persistent fog, as well as groundwater channeled along basement structures. Moreover, there are possible indications of present-day hydrologic activity provided by the RSL [22]. As such, Argyre and Valles Marineris are prime astrobiological targets [13,23].

Close in time to the Hellas impact, the Tharsis Superplume began to form with at least five subsequent stages of development [4] that would leave their mark in the Martian basins, including the northern plains [14] and the Argyre basin [13]. Recent magmatic-tectonic-hydrologic activity (<few hundred kyr) in the Tharsis/Elysium corridor, where Tharsis might be interacting with the Elysium Superplume through basement structures that intersect the intervening Amazonis and Elysium basins [24], includes possible venting in the western Elysium Planitia making it feasible to analyze recently exposed subsurface materials in situ [25].

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