DYNAMIC EARLY MARS. J.M. Dohm[1,2], R.C. Anderson[3], H. Miyamoto[2], A.G. Fairén[4], M.R. El Maarry[5], G. Komatsu[6,7], W.C. Mahaney[8], J.A.P Rodriguez[9], V.R. Baker[1], S. Maruyama[10], [1]University of Arizona, Tucson, Arizona, USA, [2]The Museum, The University of Tokyo, Tokyo, Japan, [3]Jet Propulsion Laboratory, Pasadena, California, USA, [4] SETI Institute, Mountain View, California, USA, [5]Physikalisches Institut, Universitat, Bern, Switzerland, [6]International Research School of Planetary Sciences, Università d'Annunzio, Pescara, Italy, [7]Planetary Exploration Research Center, Chiba Institute of Technology, Chiba, Japan, [8]Quaternary Surveys, Toronto, Ontario, Canada, [9]Planetary Science Institute, Tucson, AZ,USA, [10]Department of Earth and Planetary Sciences, Tokyo Institute of Technology, Meguro-ku, Japan

Introduction: The southern cratered highlands province (ACSHP) is one of several Martian provinces that when collectively pieced together distinctly detail the evolution of Mars. The various Mars provinces include ACSHP (i.e., Terra Cimmeria, Terra Sirenum, Arabia Terra, Zanthe Terra, the mountains ranges, Thaumasia highlands and Coprates rise (Figs. 1-2)), the Hellas-Argyre province, Tharsis and other volcanic provinces such as Elysium rise, Malea Planum, Hadriaca Mons, Tyrrhena Mons, Apollinaris Mons, and Syrtis Major, the northern plains province, and the Tharsis-Elysium corridor province. The geologic provinces have been identified through a synthesis of published geologic, paleohydrologic, topographic, geophysical, spectral, and elemental information [1]. In particular, ACSHP details an extremely dynamic early Mars.

ACSHP: ACSHP (Fig. 1) includes very ancient geologic terrains that are marked by magnetic anomalies [2-5]. The terrains include: (1) ancient mountain ranges, Thaumasia highlands and Coprates rise, both of which exhibit complex structures such as thrust and normal faults and rift systems, as well as cuestas and hogbacks along their margins [6-7], (2) basin and range topography [8-9], including salt-containing, structurally-controlled basins [10], as exemplified through a detailed geologic investigation of Terra Sirenum [8] and analysis of topographic profiles and crustal thickness models [9]), (3) faults that are tens to thousands of kilometers long [11], and (4) degraded promontories, many of which are interpreted as silica-rich volcanoes [e.g., 12-13] or in some cases, impact crater massifs [14].

These terrains can be aptly explained through dynamic endogenic activity, including some form of primitive plate tectonism and/or mobile crust [11,15-17], as portrayed especially during Stages 2-5 of the GEOMARS theory [18], rather than impact events or planetary shrinkage due to cooling. Such dynamic activity would forever more result in a complex basement structural fabric that would play a key role in the migration of magma and other volatiles such as water through time, including heat transfer. Subsequent activity including salt tectonism [19-20] and Tharsis development [8-9,21-22] would contribute to the complex structural history of parts of ACSHP, including formation and reactivation of pre-existing structures such as the within the Thaumasia highlands and Coprates rise mountain ranges and the structurally-controlled basins of Terra Sirenum [e.g., 8,9], as well as sequence stratigraphy such as in the giant catchment basins (e.g., Argyre).

Also during this time, giant impact basins formed, transformed into productive regional aquifers during a period of heavy precipitation, and eventually were masked by significant erosion, degradation, and burial such as exemplified by the hypothesized Arabia Terra basin; high erosion rates when compared to the present-day competed with high impact rates [18]. Such productive regional aquifers would interact with volcanic provinces such as in the case of the Arabia Terra basin and the much younger Syrtis Major volcanic field, the marginal zone of which is considered a prime target for future exobiologic investigation [24]. Other extremely ancient terrains in ACSHP include Xanthe Terra, a highly cratered terrain that occurs along the eastern margin of the north-trending Maja Valles and forms the eastern margin of an ancient Europe-sized basin [21-22]. The central and eastern parts of the circum-Chryse outflow channel system distinctly modify this part of ACSHP, and thus the surface expression of a complex basement structural fabric may be subdued when compared to other part of the highlands.

Discussion/Summary: Mars evolution can be distinctly expressed through the geologic provinces of Mars, as windows through time. In particular, a dynamic early Mars, consistent with the GEOMARS Theory [18], is detailed through ACSHP. Through the various aspects of such geologic provinces, prime targets can be identified, mapped, and characterized to address remaining queries and anomalies. These include determining: (1) what are the primary rocks that compose ACSHP, including the ancient mountain ranges, Thaumasia highlands and Coprates rise (e.g., are some of the ancient promontory-forming rock outcrops such as Claritas rise composed of granites/granodiorites?), the basin-forming materials such as observed in the Basin & Range-like topography of Terra Sirenum, and the highly degraded promontories among the structurally controlled basins that could be andesitic in composition; (2) the extent of the extremely dynamic stages of Mars evolution; and (3) whether there is extant or fossilized life in potential life-containing habits by [24].

This is a golden age of paradigm-changing, multi-disciplinary and international reconnaissance and discovery. Through such future effort, the above queries can be optimally addressed. The paradigms that Mars is a dry, dead, and mineralogically simple planet are no longer enduring. Other prevailing paradigms such as a one-plate planet through its entire history and a lifeless planet will be tested through such efforts.

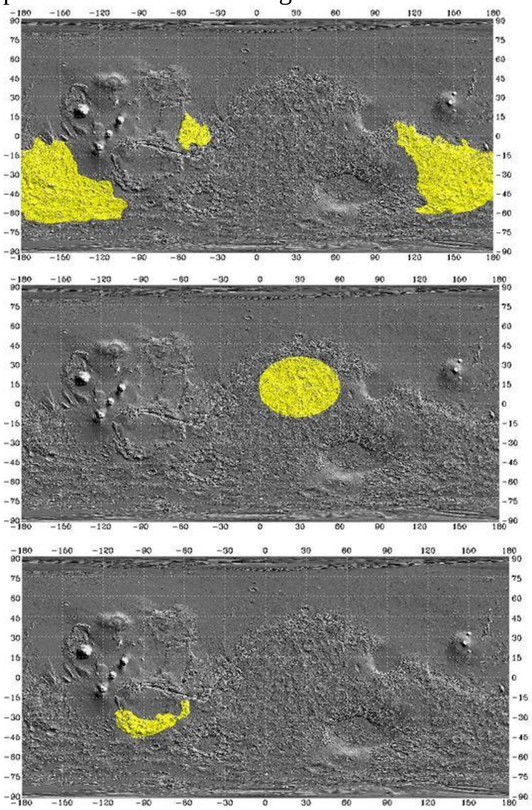

Fig. 1. ACSHP, including (top) Terra Sirenum, Terra Cimerria, and Xanthe Terra, (middle) Arabia Terra, and (bottom) the ancient mountain ranges, Thaumasia highlands and Coprates rise.

Table 1. Distinct aspects and possible associated processes of ACSHP, correlative in time with stages 1-5 of the GEOMARS Theory [18], or > 3.8Ga.

Aspect	**Aspect Description**	**Process**
Linear crustal magnetization anomalies	Linear crustal magnetization anomalies [2]; the remnant magnetization of crustal rocks implies that the Martian dynamo shut off during the Noachian Period prior to the large impact events, Hellas, Argyre, and Isidis [25])	Some form of plate tectonism [5,11,15,16,18,26]
Martian crustal variation	From thin beneath the northern plains (~30 km) to thick (~60 km) beneath the southern highlands and Tharsis [27]	Some form of plate tectonism, mantle convection associated with core formation [28]), a colossal impact event [29], and southward erosional retreat of the heavily cratered highlands [30]
Ancient mountain ranges	Thaumasia highlands and Coprates rise comprise complex structure such as thrust faults, cuestas, hogbacks [6-7]	Some form of plate tectonism, construction of a large volcanic pile that caused flexural bending of the underlying lithosphere [31], and megasliding [18]
Structurally-controlled basins	Structurally-controlled basins among highly eroded promontories and bands of strong magnetic signatures in ACSHP [1,10,11,32]	Mobile crust, including possible plate tectonism, as well as growth of Tharsis such as possible formation and reactivation of basement structures in Terra Sirenum [8-9]
Deep crustal rocks likely granitic	Deep crustal rocks likely granitic in composition [32].	Intrusive activity of felsic rocks [33], hydrothermal activity [33], heterogeneity in the mantle and crust exposed by processes such as plate tectonism [18]

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