Terra Sirenum: Window into Pre-Tharsis and Tharsis Phases of Mars Evolution

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Introduction: The Terra Sirenum region, which is located to the southwest of Tharsis, records not only the development of the Tharsis magmatic complex, at least since the Middle Noachian [1-3] up to present-day, but just as importantly, contains some of the oldest stratigraphic units of the western hemisphere region of Mars. Detailed examination of the structures and units within this region provides an excellent window into identifying the tectonic processes that influenced the geologic evolution of the ancient (pre-Tharsis) phase of the evolution of Mars. Here, we present recent results from our mapping effort detailing the geologic history of this region.

Pre-Tharsis Terrains: Pre-Tharsis tectonism in this region is expressed by 1) stratigraphic units displaying magnetic signatures, 2) largely north-trending prominent faults (defined as macrostructures [4] due to their enormous geometric proportions including lengths reaching thousands of kilometers), and 3) structurally-controlled basins (widths vary from kilometers to hundreds of kilometers) displaying water enrichment in the substrate reminiscent in many respects to the Basin and Range, southwest United States (**Fig. 1**). Some of the marcostructures might be related to the incipient development of Tharsis (*see Andrew-Hanna et al., – this conference)*.

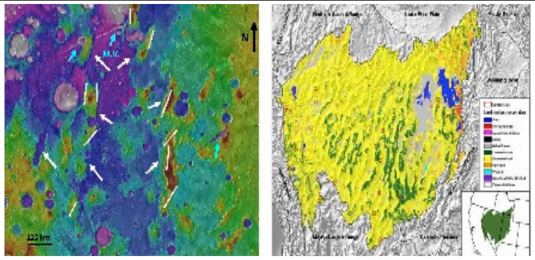

Fig. 1 Comparison between the structures identified in Terra Sirenum (white arrows) and Basin and Range topography.

Tharsis-Influenced Terrains: Susequent to such an early dynamic ancient stage of Mars evolution, the growth of Tharsis intermingled with the pre-existing Tharsis structures. Some of the structures attributed to the formation of Tharsis in this region include reactivation of ancient basement structures and the formation of the South Tharsis Ridge Belt (STRB - *see Andrew-Hanna et al., – this conference*), additional basin formation, and the formation of large faults systems (e.g., Sirenum Fossae) and dike emplacement centered about Tharsis [2-5]. There is strong evidence suggesting interplay between the macrostructures, the water-enriched structural basins, and the Tharsis-centered faults and dikes. Examples of this interplay include Mangala Valles that sources from a Tharsis-centered fault in one of the large north-trending basins and collapse structures along some of the Tharsis-centered faults, some of which display fluvial activity.

Impact Crater Perspective: Crater statistics have been completed for our stratigraphic map of the Terra Sirenum region (**Fig. 2 – Table 1**) using a new global impact crater database [6-7]. In addition, all impact craters with diameters ≥ 3 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. The superposed impact craters were additionally verified through ConTeXt camera images where there was coverage [8]. The impact crater retention ages are shown in Table 1 partly based on the modeling schemes of [9] and [10].

The following is observed through Table 1 in conjunction with the geologic mapping: (1) ancient cratered highlands basements including macrostructures are Early Noachian-Middle Noachian; (2) basin formation was established by the Middle Noachian with possible subsequent growth; (3) lavas on the western flank of Tharsis were emplaced during the Late Noachian to Late Hesperian (Stages 2-4; see [1-3]) and even as late as Middle Amazonian based on the superposed crater counts; (4) Late Noachian-Early Amazonian resurfacing of cratered highlands material, tectonic structures, and basins based on the superposed crater counts, correlative with the significant stages of Tharsis development (Stages 1-4), and (5) the source region of Mangala Valles has no superposed impact craters, indicating Amazonian resurfacing.

SUMMARY. Such ancient terrains, which record a dynamic phase in the evolution of Mars including a potentially mobile crust, merits greater attention by the Mars community. For example, what are the

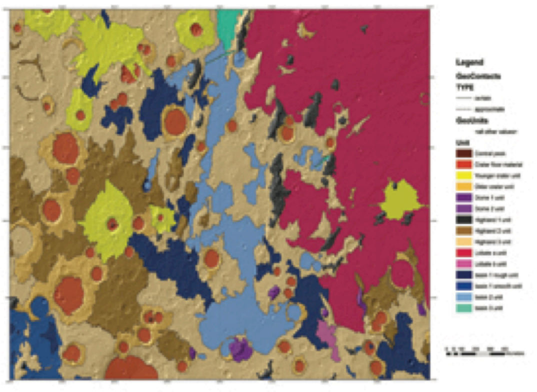

Fig. 23 Stratigraphic map of the Terra Sirenum region of Mars.

primary rocks that compose the ancient terrains and what caused the Basin and Range-like topography? Such a region could help us address whether Mars records and ancient phase of plate tectonism, perhaps very different then that of the Earth.

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Table 1. Cumalative crater densities and unit ages of geologic units in the Terra Sirenum region.

Name	Area (km^2)	Type	*N*(3)*	*N*(5)*	*N*(16)*	*N*(3) Age	*N*(5) Age	*N*(16) Age	Epoch
Basin 1 Rough Unit	257,751	T, N	632±50	407±40	144±24	3.82±0.01	3.87±0.02	3.92±0.03	MN-LN
		T, H				3.66±0.01	3.76±0.01	3.93±0.02	MN-EH
		S, N	302±34	132±23	8±5	3.68±0.02	3.66±0.04	2.12±1.3	EH-EA
		S, H				3.45±0.04	3.47±0.05	2.21±1.0	MN-LN
Basin 1 Smooth Unit	69,673	T, N	459±81	287±64	100±38	3.77±0.03	3.80±0.04	3.92±0.06	MN-LH
		T, H				3.59±0.04	3.67±0.04	3.94±0.04	EH-LH
		S, N	244±59	129±43	29±21	3.64±0.06	3.64±0.08	3.50±1.0	LH
		S, H				3.34±0.15	3.43±0.14	3.46±0.60	MN-LN
Basin 2 Unit	310,578	T, N	557±42	345±33	171±23	3.80±0.01	3.84±0.02	3.94±0.02	MN-EH
		T, H				3.64±0.01	3.72±0.01	3.95±0.02	EH-LH
		S, N	229±27	93±17	19±8	3.63±0.03	3.58±0.05	3.55±0.16	LH-EA
		S, H				3.31±0.07	3.28±0.14	3.58±0.09	LH-EA
Basin 3 Unit	19,908	T, N	402±142	251±112	100±71	3.74±0.07	3.79±0.08	3.87±0.16	MN-LN
		T, H				3.56±0.08	3.66±0.08	3.88±0.10	MN-LH
		S, N							Not Superposed
		S, H							Not Superposed
Highland 1 Unit	81,363	T, N	762±97	504±79	86±33	3.85±0.02	3.91±0.02	3.77±0.07	MN-LN
		T, H				3.71±0.02	3.80±0.02	3.76±0.05	LN
		S, N	209±51	135±41		3.62±0.06	3.67±0.07		EH
		S, H				3.27±0.20	3.50±0.09		LH
Highland 2 Unit	365,221	T, N	849±48	553±39	197±23	3.87±0.01	3.92±0.01	3.97±0.02	EN-MN
		T, H				3.72±0.01	3.81±0.01	3.97±0.01	EN-LN
		S, N	367±32	156±21	19±7	3.72±0.02	3.70±0.03	3.48±0.21	LN-LH
		S, H				3.52±0.02	3.54±0.03	3.50±0.12	LH
Highland 3 Unit	1,197,850	T, N	852±27	585±22	171±12	3.87±0.01	3.93±0.01	3.95±0.01	EN-MN
		T, H				3.72±0.00	3.82±0.00	3.96±0.01	EN-LN
		S, N	276±15	143±11	18±4	3.66±0.01	3.68±0.02	3.48±0.10	LN-LH
		S, H				3.40±0.02	3.51±0.02	3.51±0.06	LH
Lobate A Unit	922,775	T, N	200±15	118±11	59±8	3.58±0.02	3.64±0.02	3.77±0.03	LN-LH
		T, H				3.11±0.09	3.43±0.03	3.78±0.02	LN-LH
		S, N	52±8	16±4	3±2	1.99±0.29	1.27±0.33	1.03±0.60	MA
		S, H				0.87±0.10	0.65±0.13	1.12±0.48	MA
Lobate B Unit	12,084	T, N		497±203	248±143		3.95±0.06	3.98±0.11	Basement not flow
		T, H					3.87±0.05	3.99±0.07	Basement not flow
		S, N							Not Superposed
		S, H							Not Superposed
Older Cratered Unit	305,477	T, N	593±44	344±34	72±15	3.81±0.01	3.84±0.02	3.81±0.04	MN-LN
		T, H				3.66±0.01	3.73±0.01	3.82±0.03	MN-EH
		S, N	249±29	121±20	13±7	3.65±0.03	3.64±0.04	3.42±0.62	EH-LH
		S, H				3.38±0.05	3.44±0.06	3.46±0.24	LH
Younger Cratered Unit	272,632	T, N	873±57	381±37	114±20	3.87±0.01	3.86±0.02	3.87±0.03	MN
		T, H				3.73±0.01	3.74±0.01	3.88±0.02	MNMN-LN-LN
		S, N	293±33	139±23	18±8	3.68±0.02	3.68±0.03	3.48±0.35	EH-LH
		S, H				3.45±0.04	3.51±0.04	3.50±0.16	LH

*Crater density is per 10^6 km^2