GEOLOGIC DIVERSITY AND CHRONOLOGY OF HESPERIA PLANUM, MARS. David A. Crown[1], Daniel C. Berman[1], and Tracy K.P. Gregg[2], [1]Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, AZ 85719, crown@psi.edu, [2]Department of Geology, 876 Natural Sciences Complex, University at Buffalo, Buffalo, NY 14260.

Introduction: Hesperia Planum is characterized by a vast expanse (> 2 million km^2) of ridged plains that fill a low-lying region in the cratered highlands NE of Hellas Basin [1-5]. Hesperia Planum also contains Tyrrhena Patera, an ancient volcano with a main pyroclastic shield and a late-stage lava flow field that extends SW for over 1000 km [6-7]. In Viking Orbiter studies, ridged plains were interpreted to consist of voluminous lava flows that post-date Tyrrhena Patera's eroded shield, but pre-date its late-stage effusive eruptions. The impact crater population of the ridged plains has been used to define the base of the Hesperian System [2, 8], making Hesperia Planum a key location for Martian stratigraphy.

Recent studies have recognized significant fluvial modification of parts of southern Hesperia Planum and the surrounding highlands [3, 9-14], as well as re-evaluated the extent of Tyrrhena Patera, particularly to the west and southwest [6, 15-16]. These detailed analyses demonstrate a previously unrecognized geologic diversity to Hesperia Planum and a distribution of ridged plains (characterized by wrinkle ridges and ridge rings) markedly different than represented on the 1:15M-scale geologic maps of Mars [2]. To provide a synthesis of its geologic history, a new geologic map of Hesperia Planum is being compiled at 1:1.5M scale [16-19]. In conjunction with this effort, here we examine the distribution and nature of sedimentary and volcanic units within southern Hesperia Planum and provides new constraints on the formation and modification of Hesperia Planum from recompiled Viking Orbiter crater statistics and new crater size-frequency data from MOC, THEMIS, and HRSC images.

Tyrrhena Patera and Surroundings: Geologic units associated with Tyrrhena Patera have been mapped as part of regional and global inventories [2, 5, 20-21] and more detailed volcanic studies [6, 9-10, 15, 22-24]. The shield materials defining the volcano's main construct are thought to be composed of layered pyroclastic deposits that are dissected by a system of radial erosional valleys, whose wide, flat floors and nested morphology are suggestive of modification by sapping processes [6, 25-26]. THEMIS VIS images show small valley networks on the floors of the larger erosional troughs, indicating sustained surface runoff [27]. Extending SW from Tyrrhena Patera's summit is an extensive flank flow unit consisting of numerous lava flow lobes (with typical lengths > 100 km) and volcanic channels [6, 9, 23].

To the west and NW of Tyrrhena Patera, relatively flat-lying, smooth plains are observed [5-6]. Numerous scarps indicate a similar erosional style to Tyrrhena Patera shield materials and suggest layering in some localities. Greeley and Crown [6] mapped Hesperian smooth plains that they interpreted to be a facies of the ridged plains or a basal unit of Tyrrhena Patera. Recent work has suggested that primary and reworked pyroclastic materials from Tyrrhena Patera dominate the region NW of the volcano [15-16, 28]. To the SW, smooth, lightly cratered plains separate units clearly associated with Tyrrhena Patera from the highlands of Tyrrhena Terra. In THEMIS IR images, this region, which was originally included in the Hesperian smooth plains unit of Greeley and Crown [6], appears to be young, at least partially sedimentary deposits that embay the cratered highlands and are exposed in sinuous canyons which are oriented along the regional slope to the SW. Both the canyon floors and plains surfaces show narrow, sinuous valleys of fluvial origin.

Southern Hesperia Planum: At its southern margin (S of Tyrrhena Patera), Hesperia Planum shows evidence for local surface dissection by fluvial valleys. Drainage extends through remnants of the rugged highlands of Promethei Terra onto lower lying surfaces adjacent to the Tyrrhena Patera flank flow unit. Mest and Crown [10] mapped this region as a dissected plains unit, noting the subdued character and decreased number of wrinkle ridges relative to the ridged plains proper. Significant drainage is evident within southern Hesperia Planum in the form of the upper reaches of Reull Vallis, which provide clear evidence for collapse of ridged plains and fluvial erosion. Topographic lows have been noted within Hesperia Planum that may have been sites of surface water accumulation [13, 29]; the Morpheos basin, defined in recent work [3, 30], may have stored water that contributed to formation of the Reull Vallis canyon system downstream. A narrow sinuous channel system parallel to and east of Reull Vallis extends south toward large expanses of knobby plains, which may represent the extent of a former and larger highland sedimentary basin [29].

Age Constraints from Crater Statistics: Crater statistics for geologic units/areas of interest within Hesperia Planum have been compiled for craters ≥ 5 km in diameter using contacts/boundaries defined in previous studies and the Barlow martian crater database [31]. Using ArcGIS, craters in the database intersecting each unit were examined to identify those superposed on the surface of interest; the Barlow database contains flooded craters and ridge rings, which were distinguished from superposed craters using Viking Orbiter and THEMIS IR mosaics. Many of the units include numerous, large, partially to completely buried/flooded craters that significantly alter age derivations. N(5) and N(16) crater statistics and analysis of size-frequency distributions support previous interpretations of ancient ages for Tyrrhena Patera and Hesperia Planum. The crater-derived age of the Morpheos Basin region (defined by the 650 m contour) indicates that this is also an ancient surface, suggesting that any paleolake present here was also ancient or was shallow enough not to have affected craters with diameters ≥ 5 km. Surface morphology and crater statistics suggest that a diversity of processes has shaped Hesperia Planum over a prolonged time period. The Tyrrhena Patera flank flow unit represents younger volcanic activity in the region, clearly postdating the main shield and ridged plains; smooth and dissected plains record fluvial activity, at least some occurring well after formation of ridged plains. Future work will include integration of small crater populations from MOC, THEMIS, and HRSC images to refine age constraints and to investigate styles and sequences of degradation across Hesperia Planum.

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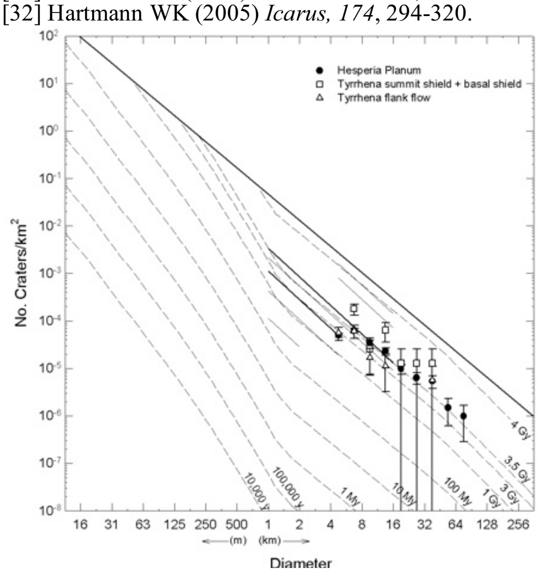

Figure 1. Crater size-frequency distributions for units in the Hesperia Planum region, plotted on Martian isochron system [32]. Plot shows progression in age (oldest to youngest) from 1) Tyrrhena Patera shield materials to 2) ridged plains of Hesperia Planum to 3) Tyrrhena Patera SW flank flow unit.

Geologic Unit/Area	Contacts/ Boundaries	Area (km^2)	# Craters > 5 km	N(5)	N(5) Age Range	N(16)	N(16) Age Range
Hesperia Planum-ridged plains	[2]	2,044,691	354	173±9	EH	24±3	LN-EH
Tyrrhena Patera	[2]	50,672	15	296±76	LN	20±20	EH
Tyrrhena Patera							
Caldera-fill	[6]	1670	0	----	----	----	----
Summit shield	[6]	18,880	7	371±140	MN-LN	----	----
Basal shield	[6]	59,168	19	321±74	LN	51±29	LN-EH
Flank flow unit	[6, 23]	179,619	23	128±27	EH-LH	6±6	EH
Smooth plains	[6]	165,006	26	158±31	EH	30±14	LN-EH
Dissected plains	[10]	122,074	10	82±26	LH-EA	33±16	LN-EH
Morpheos Basin	[3, 29]	238,765	36	151±25	EH	34±12	LN-EH
Hesperia Planum minus Tyrrhena Patera units and Dissected plains	----	1,498,273	269	180±11	EH	24±4	LN-EH

Table 1. Crater statistics and age constraints for Hesperia Planum region, Mars. Areas calculated with ArcGIS 9.1 using contact/boundaries from previous studies and craters ≥ 5 km in diameter from [30]. N(5) and N(16) are cumulative number of craters with diameters ≥ 5 and 16 km (respectively) normalized to 10^6 km^2. Age ranges (epochs) determined using crater density boundaries of Tanaka [8]: MN = Middle Noachian, LN = Late Noachian, EH = Early Hesperian, LH = Late Hesperian, EA = Early Amazonian.