STATUS OF 1:24,000-SCALE GEOLOGIC MAPPING OF BASIN STRATA EXPOSED IN CENTRAL HADRIACUS CAVI, MARS. J. A. Skinner, Jr. and C. M. Fortezzo, Astrogeology Science Center, U. S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001 (jskinner@usgs.gov).

Introduction: The availability, areal coverage, and overlapping nature of high-resolution images of Mars affords increased focus on previously unobservable characteristics and stratigraphic relationships of units, and groups of units, that outcrop in exhumed basins across that planet [*e.g.*, 1]. These characteristics and their lateral relationships can provide important clues to the evolution of sedimentary basins on Mars, including details about the interaction between tectonism, local to regional impact events, volcanism, sedimentary processes, and paleoclimate. Methods and results of scale- (standardized) and non-scale-based (topical) geological mapping at local scales both play a role in deciphering these critical details about Mars' past, particularly when matched with past geological mapping results at contrasting scales. Here, we present results of ongoing geological mapping of the stratified deposits exposed in Hadriacus Cavi (78.0ºE, -27.3ºN) based on 1:24,000 scale mapping of HiRISE images and stereo-derived topography.

Geologic Setting: Hadriacus Cavi are a 65 km long, 15 km wide set of irregularly-shaped, east-west oriented depressions located in the cratered highlands of southwest Tyrrhena Terra, along the northeastern rim of the Hellas basin (**Fig. 1A**). The cavi are bound on the south by topographic massifs (unit eNhm of [2]) and on the north by Hadriacus Palus, a nearly horizontal plain (unit lNh). The palus itself is broadly surrounded on the north, east, and south by linear, arcuate, and quasi-circular, faceted massifs as well as gently sloping, moderately rugged surfaces (units eNh and mNh). Channels dissect bounding terrains. with orientations implying local centripetal drainage toward the palus. Small-scale mapping suggests the regional landscape evolved through fluvial and gravity-driven erosion of Hellas-related uplifted crustal massifs and transport and deposition of detritus across into intercrater basins [2-3]. However, these processes are not spatially or temporally constrained at local scales. Thus, basin-related processes remain indeterminate.

Our mapping focuses on strata that outcrops in central Hadriacus Cavi (**Fig. 1B**), extending from the generally smooth palus surface (~-2600 m elevation) to more rugged terrains (~-2167 m elevation), which are located immediately north of a 1600-m tall massif (outside of the study area). Therein, the cavi expose >500 meters of strata across the length of the map region, including multiple chasmata of variable depth and topographic interconnectivity. The strata generally consist of laterally traceable light- and dark-toned layers of variable thickness. Light-toned groups contain thin (meter-scale) dark-toned layers, are volumetrically dominant, and tend to form sloping surfaces. Dark-toned groups tend to form topographic benches, particularly where these layers are observed to be a few meters thick. Slopes, benches, and chasma floors are often obscured by intermediate- to dark-toned surficial units, including areally expansive dune fields.

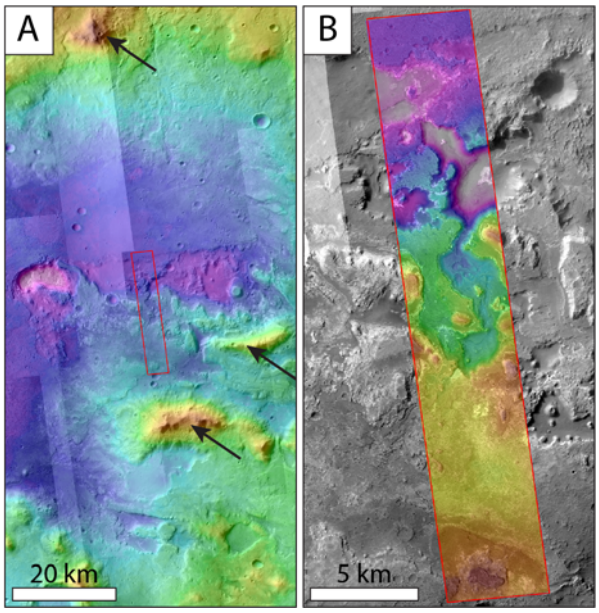

Figure 1. Setting of study area. (A) Regional view shows Hadriacus Palus and Cavi along with bounding massifs (black arrows) and moderately-rugged intercrater plains. Study are shown by red box. HRSC DTM (red high, white low) overlain on CTX mosaic. (B) Local view shows slopes, benches, and chasmata. Note gentle northward slope (~1º). HiRISE stereo-derived DTM overlain on orthoimage and CTX mosaic.

Datasets and Methods: Our mapping, descriptions, and analyses are based on a SOCET Set-derived [4] digital terrain model (DTM) (clon=78.04°E, 1.5 m/px) and associated orthoimages (0.5 m/px) using HiRISE stereo-pairs ESP_031924_1525 and ESP_032069_1525. Base data were supplemented by HiRISE gray-scale images (registered to DTM-derived orthoimages) to assist with unit identification and description and CTX image mosaics, HRSC mosaics and DTMs, and THEMIS daytime IR mosaics to assist with linking local observations to immediately surrounding terrains. Data were displayed and mapping completed in Esri's ArcGIS software, assisted by 3-

dimensional rendering in ArcScene and extracted topographic cross-sections. We keyed off a single stratigraphic unit ("level 0") that is broadly observed in the study region, which provides a relative marker bed for identifying and interpreting the local stratigraphy. Stratal orientations are estimated based on best fit planes defined by user-selected points along a common surface. We define map units based on lateral continuity of distinct "groups" of strata, with dark-toned, bench-forming sub-units generally forming the base of distinct groups.

Results: We currently identify 15 units within the Hadriacus Cavi study region, including 6 surficial units (ejecta 1, ejecta 2, dunes, non-dune mantle, colluvium, and talus) and 9 stratified units (described below). Though the surficial units comprise ~30% of the total map area and are useful for lateral correlations, the stratified rocks are of elevated importance with regard to the basin stratigraphy. Therein, we group the stratified rocks into upper, middle, and lower groups that are (mostly) vertically and laterally consistent. All gently slope 2-4º to the northwest (with local variability).

Upper group. The "upper group" resides above the "level 0" marker, represents ~200 meters of cavi-outcropping strata, and is generally light-toned and finely to massively stratified. This group tends to form broad, linear to quasi-circular mounds and hillocks that are several hundred meters to several kilometers in width. From top to bottom, this group contains (1) a 50-meter-thick light- and dark-toned series of massively-stratified rocks that contain decameter-scale surface polygons and which erode into undulating scallops and narrow, mantle-covered benches, (2) a 80-meter-thick, mostly-light-toned series of moderately-stratified rocks that contain multiple narrow benches, with characteristic circular, mantle-filled depressions and a basal dark-toned unit (and associated bench), and (3) a 70-meter-thick, finely-stratified rocks that are expressed mostly as a single, sloping surface of wall-rock with a basal dark-toned unit. The upper group contains the least surficial cover of all stratified groups in the region.

Middle group. The "middle group" contains the "level 0" marker, represents ~90 meters of cavi-outcropping strata, and is generally finely-stratified throughout. This group tends to be capped by a broad bench that is identifiable through most of the map region and a single main scarp and slope. From top to bottom, this group contains (1) a 40-meter-thick dark-toned series of rocks with several light-toned interlayers whose surface is characterized by a mantle-covered scallops and pits ("level 0") and whose wall-rock expression is a dark slope with only minor benches, and (2) a 50-meter-thick light- and dark-toned series of rocks that erode into layered wall rock and characteristically contain multiple asymmetric, light-toned lenses with level surfaces (typically occurring at ~2550 m elevation). The wall rock slope of the middle group is commonly overlain by dark-toned dunes and sloping colluvium, the latter of which is often eroded into scallops.

Lower group. The "lower group" resides below the "level 0" marker, represents ~230 meters of cavi-outcropping strata, and is demonstrably dark-toned with few, interspersed light-toned layers observed. This group tends to form both slopes and low-lying benches, the latter of which commonly contain numerous circular depressions. From top to bottom, this group contains (1) a 50-meter-thick series of rocks with upper light- and dark-toned layers and lower dark-toned layers with minor benches, (2) a 90-meter-thick series of dominantly dark-toned rocks that contain segments of channel-like sinuous depressions on their upper surface, (3) a 60-meter-thick series of dominantly dark-toned rocks with few internal benches, and (4) an >30-meter thick series of light-toned rocks with thin dark-toned intervening layers that occurs on the floor of the deepest local chasmata (~-2806 m elevation). The lower group contains the most surficial cover of any stratified rocks in the study region and often appears to grade between sloping colluvium.

Discussion: Our 1:24,000-scale geological mapping and stratigraphic analyses has identified a complex geological history for the strata exposed in Hadriacus Cavi that includes deposition (including by volcanic and fluvial processes), subtle tectonism, and widespread erosion. Local crater counts [3] suggests this activity occurred over 600 Ma from the Middle Noachian to Late Hesperian. Though a lack of observable unconformities supports a hypothesis that the region underwent a single cycle of deposition and erosion, subtle correlations between major unit groups may indicate up to three major episodes of deposition and erosion, perhaps correlating with divisions between major unit groups. Surficial cover is a major complication to unravelling the local depositional history. Remaining work focuses on unit descriptions, cartographic representations of subtle landforms, and type section construction and correlation.

References: [1] Grotzinger, J. P. and Milliken, R. E. (2012) *SEPM Sp. Pub. 102*, p. 1-48. [2] Tanaka, K. L. et al. (2014) *USGS SIM 3292*, 1:15M scale. [3] Fortezzo, C. M. and Skinner, J. A., Jr. (2013), *LPS XLIV*, Abstract #2104. [4] Kirk R.L. et al. (2009) *LPS XL*, Abstract #1414.

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