GEOLOGIC MAP OF THE OLYMPIA CAVI REGION OF MARS (MTM 85200): A SUMMARY OF TACTICAL APPROACHES.

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Introduction: The 1:500K-scale geologic map of MTM 85200—the Olympia Cavi region of Mars—has been submitted for peer review [1]. Physiographically, the quadrangle includes portions of Olympia Rupēs, a set of sinuous scarps which elevate Planum Boreum ~800 meters above Olympia Planum. The region includes the high-standing, spiral troughs of Boreales Scopuli, the rugged and deep depressions of Olympia Cavi, and the vast dune fields of Olympia Undae. Geologically, the mapped units and landforms reflect the recent history of repeated accumulation and degradation. The widespread occurrence of both weakly and strongly stratified units implicates the drape-like accumulation of ice, dust, and sand through climatic variations. Similarly, the occurrence of layer truncations, particularly at unit boundaries, implicates punctuated periods of both localized and regional erosion and surface deflation whereby underlying units were exhumed and their material transported and re-deposited. Herein, we focus on the iterative mapping approaches that allowed not only the accommodation of the burgeoning variety and volume of data sets, but also facilitated the efficient presentation of map information. Unit characteristics and their geologic history are detailed in past abstracts [2-3].

Tactical Approach: Like many recent Mars geologic maps, this map was completed during a time of especially high data flux and evolving digital mapping techniques. The 2009 Mappers Handbook [4] provided guidance for the construction of geologic maps, focusing on temporally and fiscally efficient drafting, review, and production. We adhered to the general structure of these recommendations, as outlined below.

GIS Parameters. We used ArcGIS to co-register and analyze available datasets. Vector linework was digitally streamed at a constant scale of 1:125K (25% of the publication map scale), which is sufficiently detailed for both hard-copy and digital map publications. Linework was streamed directly into a GIS database in Polar Stereographic projection using a digital mapping tablet. Vertices were placed every 125 meters (1 vertex per 1 mm at 1:125K digitizing map scale) and attributes were assigned using an attribute domain stored within the geodatabase. Geologic map symbols were derived from FGDC Digital Cartographic Standards for Geologic Map Symbolization and adapted where necessary to convey the geologic information unique to the quadrangle. Contact linework was cleaned, smoothed, and used to build unit polygons. Subsequent editorial iterations of the digitized linework allowed for refinement of contact placement and unit descriptions based on cross-comparison between the map base and supplemental data sets.

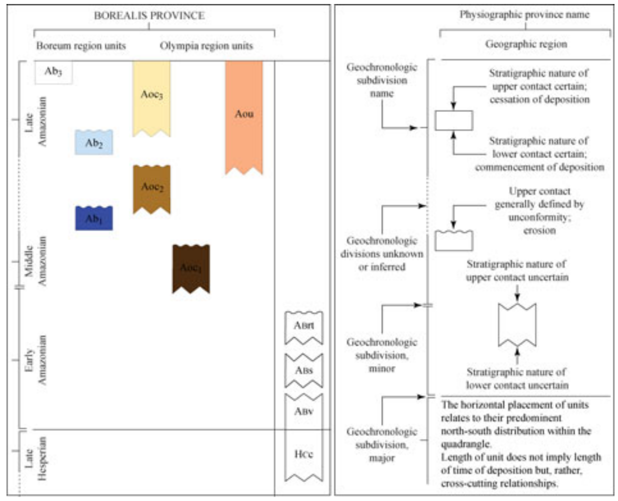

Figure 1. COMU organization, reference units, and key.

Base Maps. The primary base map for this geologic map was a Viking Orbiter mosaic constructed from frames acquired during the 1976 Martian northern summer (L_S from 133 to 135; 50 m/px). The original intent of the Viking base mosaic was to provide a time-controlled view of the polar ice during its presumed minimal extent and with the absence of obscuring seasonal frost [5]. However, to include the topographic detail afforded by MOLA, we overlaid the Viking mosaic with the MOLA polar DEM (115 m/px). Unit delineation and description was explicitly tied to the blended base map due to its near-complete areal coverage of the selected quadrangle (~0.4° latitude of data non-existent for MOLA at the northern boundary of the map region due to orbit of Mars Global Surveyor).

Supplemental Data. Base map linework was refined by integrating other data sets, including MOLA-derived products (cell-to-cell slope, aspect, and color-shaded relief maps) and the full range of THEMIS, MOC, HiRISE, and CTX images via web-linked image footprints. The areal discontinuity of high resolution data sets along with the scale of geologic detail (compared to published map scale) reduced their utility to an important, but supplemental, role in geologic mapping. High-resolution data sets were strategically and selectively employed to delineate and define geologic units and assess stratigraphic relationships. Their use was limited to those instances where critical geologic characteristics were consistently observable despite incomplete spatial coverage.

Unit Names and Symbols. We named geologic units with non-morphologic, non-genetic terms and grouped these into two regions. The "Boreum region units" are those that comprise the polar flats and troughs of Planum Boreum, generally located north of the Olympia Rupēs (3 units). The "Olympia region units" are those that occur within and adjacent to the Olympia region of Mars, generally located south of the Olympia Rupēs (4 units). Unit names reflect their geographic occurrence as well as their stratigraphic relationship to one another. Unit symbols identify (1) the chronologic period (**A**=Amazonian period), (2) the geographic region unit (**o**=the Olympia region), (3) physiographic feature name where more than one geologic unit occurs in a region (**c**=Olympia Cavi), and (4) the interpreted stratigraphic sequence (1=the first of two or more related geologic units). Therein, the geologic symbol "$\mathbf{Aoc_1}$" refers to the Amazonian-age, stratigraphically-lowest unit that occurs within and/or adjacent to Olympia Cavi. This scheme differs from that applied by [6] due to a lack of global physiographic province in MTM 85200.

Description of Map Units (DOMU). We compiled unit descriptions in tabulated format, adhering to the recent guidelines [4]. Unit groupings, appearance, and stratigraphic relationships were determined based primarily on their appearance in the base map, which provided the most consistent areal extent and resolution; supplemental data sets provided unit characteristics where they were consistently observed and critical to the interpretation (see above sections).The tabulated description of map units uses bulleted "primary" and "supplemental" characteristics, which are consistently listed for each unit. Supplemental characteristics include high resolution image numbers for reference. In addition, we included an "other names" field that listed alternative published names for mapped units (or variants thereof) located both within and outside of the quadrangle boundary [7]. We also produced a classical, prose-based DOMU, which included equivalent information.

Correlation of Map Units (COMU). The paucity of impact craters within the map area precluded the confident assignment of stratigraphic divisions using crater statistics. As such, epochs were assigned based on the contextual work of previous publications [6-10]. Units were organized within the COMU based on their occurrence and distribution within each region. For reference and textual clarity, we included reference units from past work as well as a "key." The latter provided a guide to the visual depiction of stratigraphic relationships between units mapped within the quadrangle. We also compiled a table showing relative ages, areas, and superposition relationships.

Figures. We used three figures to summarize the contextual geologic and stratigraphic information. One figure showed regional topography of the map region via a MOLA color shaded relief image, which included IAU-approved nomenclature. In addition, two figures were constructed from CTX image excerpts that showed key unit outcrops and stratigraphic relationships. The figures are annotated with geologic contacts and figure locations and extents are shown on the map. We submitted multiple annotated figures based on excerpted high resolution images that we suggest be published solely as digital supplements. The intent was to minimize map size as well as production costs by supplementing the map with figures deemed important but not necessarily critical to the conveyance of map information. Supplemental figures are referenced as such within the geologic map text.

Conclusions: Digital data volumes and mapping environments allow for the characterization of geologic units and relationships well below the limitations of the expected publication scale of geologic maps. A balanced mix of scale-based observations and succinct descriptions is critical for the efficient production of geologic maps. From a tactical standpoint, we conclude:

- Consistent use of a map scale and digitizing parameters provides a documentable means for delineating and describing geologic materials and relationships using several, overlapping, multi-scale data sets.
- Map scale necessitates a conscious division between primary and supplemental data sets. The volume, type, resolution, and areal diversity of available data necessitate thoughtful preference and down-selection so that maps are completed in a timely manner.
- The naming and symbolizing of geologic units is scale dependent and is assisted by including physiographic province and region.
- Including reference units (from previous map publications) and a "key" in the COMU diminishes the need for equivalent explanation in the geologic map text.
- Annotated figures showing key outcrops and unit relationships are critical to conveying the map information. Digital supplements assist with limiting text size.
- DOMU tabulation is an extremely helpful way to collate and efficiently present unit characteristics from both primary and supplemental data sets.
- Geologic mapping strategies require continued optimization so that best practices are employed for the production of clear, consistent geologic map information.

References: [1] Skinner and Herkenhoff, Geologic Map of the Olympia Cavi region of Mars, 1:500K scale (in review). [2] Skinner and Herkenhoff (2007) *PGM 2007 abstract volume*. [3] Skinner and Herkenhoff (2006) *PGM 2006 abstract volume*. [4] Tanaka *et al.* (2009) Plan. Geo. Map. Handbook, *PGM 2009 abstract volume*. [5] Herkenhoff (2003) *USGS I-2753*, 1:500K scale. [6] Tanaka *et al.* (2005) *USGS SIM 2888*, 1:15M scale. [7] Tanaka *et al.* (2008) *Icarus* 196, 318-358. [8] Blasius *et al.* (1982) *Icarus* 50, 140-160. [9] Herkenhoff and Plaut (2000) *Icarus* 144, 243–253. [10] Tanaka (2005) Nature 437, 991-994.