COMPLETING THE NEW GLOBAL GEOLOGIC MAP OF MARS.

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Introduction: We have completed the fourth year of a five-year effort to map the geology of Mars at 1:20,000,000 scale using mainly the Mars Global Surveyor Mars Orbiter Laser Altimeter (MOLA) digital elevation model (DEM) at 460 m/pixel and the Mars Odyssey Thermal Emission Imaging Spectrometer (THEMIS) infrared (IR) global image mosaics (day and night time; 100 m/pixel) supplemented in places by other available orbiter imaging datasets. Previously, we have reported on initial aspects of project management, mapping datasets (local and regional), initial and anticipated mapping approaches, tactics of map unit delineation and description, and preliminary mapping results, focusing on Amazonian units and fault mapping [1–4]. Here, we describe new and updated aspects of our mapping approaches, progress to date, current issues, and plans for completion. (Versions of the map compilation will be presented at this conference and at the mappers meeting in June 2011.)

Flow-unit mapping: We recently made a significant departure in mapping approach from the previous global geologic map of Mars based on Viking data [5], involving extensive flow sequences that chiefly occur in the Tharsis region. Previous 1:15M scale mapping resulted in a sequence of 6 units emanating from Tharsis Montes, as well as additional flow units sourcing from Olympus Mons (2 units), Alba Mons (3), and Ceraunius Fossae (1). Additional flow units occur in Syria and Solis Plana and the Elysium and Hellas regions. These lava sequences, however, have few well-defined contacts that can be used confidently to enclose polygons and define units (i.e., a well-defined margin can be identified and mapped locally, but elsewhere it is ill-defined). While some patches of flows were erupted from various isolated vents over extended time periods, such that broad, contiguous groups of similar-age flows cannot be discriminated, others may mark distinct emplacement phases.

As a consequence, we are not forcing closure of contacts where geologic relations are ill-defined. Rather, where such is the case, our approach is to map prominent flow directions using arrows, as well as flow-lobe margins of significance such as a major flow sequence of possible similar age using a distinct map symbol. Thus the map reader can detect the source locations and extent of flow sequences and where local hiatuses in flow activity may have occurred. In some cases, flow arrows with opposing directions may define where flow systems meet, but a lack of clear geomorphic relations has prohibited discrimination of flow units. Delineation of flow sequences not only marks possible major emplacement phases, but also potential major hiatuses between emplacement phases. Overall, the history of flow emplacement on Mars, based on a conservative mapping approach, is highly generalized at global scale on Mars; greater detail is possible but requires mapping and crater counting at local to regional scales [e.g., 6, 7].

Mapping size constraints: We are striving to construct a map with consistent geometric constraints appropriate to the global scale. Our digital drafting using geographic information system (GIS) software is streamed with a spacing of 5 km between vertices. Unit outcrops, including crater material, must meet a minimum size requirement of 100 km long and 40 km wide. Line structures must be >100 km long. Mapped crater rims must exceed 100 km in diameter.

Line feature attribution: Planetary geologic map symbol sets typically mix geomorphic observation and geologic interpretation. For example, mapped symbols might include lineaments, grabens, wrinkle ridges, ridges, valleys, lobate flow fronts, small shields, small craters, etc. In some cases, the degradational state may be noted, such as ”fresh” vs. ”subdued” [8]; their geometric form may be discriminated, such as ”asymmetric” vs. ”symmetric” [8]; and they may be distinguished by size (e.g., length, width, diameter [e.g., 9]) and by primary vs. secondary origin [10], etc. This approach commonly forces the reader to unravel the observational vs. interpretational components of the feature mapping.

Our digital mapping approach provides tools to aid in sorting out observation and interpretation, and in keeping various aspects of each feature organized and consistently defined. Specifically, we construct an attribute table (see Table 1) for each line feature that discriminates the feature’s primary class (e.g., scarp, ridge, trough, crater rim, valley), secondary class (e.g., simple scarp, lobate scarp), size range (optional; e.g., narrow vs. wide), degradational/burial state (fresh, subdued, partly buried). We also indicate in the table the geologic interpretation in primary classes (e.g., tectonic, erosional) and secondary classes (graben, contractional structure, fracture, etc. for the tectonic class).

Additional attributing involved contacts. We map two contact types—certain and approximate. The latter type includes what other maps distinguish as gradational and/or inferred.

No area or point features: Given our line feature mapping approach and the scale and scope of the global map, we thought that it would be overwhelming to attempt to map secondary terrain types superposed on map units (e.g., polygonal troughs and thumbprint terrain [8]) or point features (e.g., small shields or vents, small craters, fan deposits, etc.). If we were to apply our approach to discriminate observation and interpretation, then we would be forced, for example, to map all knobs and hills larger than a given size, then provide additional geomorphic and geologic information for each of many thousands of features. Such mapping and tabulating work is best done independently as either local to regional mapping projects or global inventories. If prepared in GIS, such mapping could then be imported into the eventually published digital geologic map. In some cases, regional and global digital maps of valleys, basins, debris aprons, volcanic vents and flow types, and other features have already been completed or are in progress [e.g., 6-8, 11-13].

Map compilation: At the time of this writing, the initial map was being assembled, homogenized, and edited. Each regional mapper supplied linework for unit contacts and line features. The line features were being collated, edited, filled in where needed, and attributed by C. M. Fortezzo to ensure a consistent portrayal and adherence to our mapping and attributing guidelines (Table 1). In areas around Tharsis, where mapping of tectonic features is overly dense for full portrayal at global scale, emphasis was placed on inclusion of the major trends. Then, as space permits, additional features defining the span of densely spaced fault systems were included.

Table 1: Examples of linear feature attribution.

Morphology[1]	Origin[2]	Interpretation[3]	Preservation[4]
Trough	Tectonic	Graben	Subdued
Ridge	Tectonic	Wrinkle Ridge	Fresh
Depression	Impact	Crater	Partially Buried
Trough	Fluvial	Valley	Subdued

[1] Morphologic descriptor: Nongenetic feature description

[2] Origin descriptor: Process that created the feature

[3] Interpretation descriptor: Genetic feature description

[4] Preservation descriptor: Fresh, subdued and partially buried

An extensive task underway has been to revise the contact mapping and unit assignements so that the map once again adheres to our own guidelines and schemes. K.L. Tanaka was performing a comprehensive review of each mapper's individual work, with the objective of achieving consistency in map unit assignments, completeness and adequacy of defined map units, and consistent application of outcrop size constraints (including finding unmapped outcrops). Where needed, C.M. Fortezzo has been tasked to simplify overly detailed linework drafting. Once the map is revised by the regional mappers (Dohm, Irwin, Kolb, and Skinner) as needed based on this initial review, each mapper will have opportunity to review the regions mapped by the other mappers and the feature mapping of C.M. Fortezzo.

The mappers have also been defining type areas and subtype areas, in cases where more than one characterization is helpful. Because we are generally drafting linework while viewing the mapping bases at 1:5,000,000 scale, we are selecting 100-km-square boxes (2.5 cm square at scale) of the units using the THEMIS daytime IR transparently over the MOLA DEM, which we intend to place on the printed map in the margins next to each unit description.

Age-dating units: Once the map is compiled, we will determine crater densities for each polygon using the global crater database for diameters >1 km nearing completion by Robbins and Hynek [14] . Based on these results, we will adjust outcrop unit designations as needed. For more in-depth age characterization and resurfacing analysis, detailed crater counts of the type areas and other important areas will be performed by T. Platz.

Once we have all the mapping relative-age relations and crater-counting data compiled, we will make final age determinations for each unit. All of the required data will be included as digital supplements in the published map.

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