MARS GLOBAL GEOLOGIC MAPPING PROGRESS AND SUGGESTED GEOGRAPHIC-BASED HEIRARCHAL SYSTEMS FOR UNIT GROUPING AND NAMING. K.L. Tanaka[1], J.M. Dohm[2], R. Irwin[3], E.J. Kolb[4], J.A. Skinner, Jr.[1], and T.M. Hare[1], [1]U.S. Geological Survey, Flagstaff, AZ, ktanaka@usgs.gov, [2]U. Arizona, Tucson, AZ, [3]Planetary Science Inst., Tucson, AZ, [4]Google, Inc., CA.

Introduction: We are in the fourth year of a five-year effort to map the global geology of Mars at 1:20M scale using mainly Mars Global Surveyor, Mars Express, and Mars Odyssey image and altimetry datasets. Previously, we reported on details of project management, mapping datasets (local and regional), initial and anticipated mapping approaches, and tactics of map unit delineation and description [1-2]. Last year, we described mapping and unit delineation results thus far, a new unit identified in the northern plains, and remaining steps to complete the map [3].

Progress: This past year, mapping of much of the highlands, northern plains, and polar regions have been completed in preliminary form, including linework, unit naming, and definition (including type localities). However, considerable mapping remains for Tharsis and parts of the highlands. For map-unit dating, we have shown with the help of Stephanie Werner (U. Oslo) how some of the units in the northern plains appear to be regionally time-transgressive [4]. In addition, Werner and Tanaka are preparing a paper addressing how to more precisely tie crater size-frequency distributions to the Martian epochs [5] for both Hartmann and Neukum crater production functions [6]. This paper will make age assignments for Mars a bit more clear, although the great disparity between the Hartmann and Neukum distributions continues to be problematic.

Unit-group naming scheme: Various systems of unit groupings and hierarchies appear in geologic maps of Mars. In comparing Mars maps, as shown in Table 1, we find a disparity in the terminology used, which leads to ambiguity and confusion [7-12].

For example, the Viking-based global geologic map of Mars [7] and the post-Viking map of the northern plains region [8] are both widely referenced and show why the current approaches need clearer definition. The highest unit rank in [7] includes "lowland terrain, highland terrain, and north and south polar region units," as well as "materials occurring throughout map area." The second order groups include various assemblages and a "channel-system and eolian materials" grouping. The third level includes formations, materials, units, deposits, a plateau sequence, and a paterae category. In turn, formations are divided into members, and polar deposits are subdivided. In the case of [8], the regional designations are all named "provinces," and all map units are designated "units," including those that would be included at both the formation and member levels.

Other Mars maps add further labels used in unit rankings, such as "material(s)" and "deposits" for the second rank in Table 1 [e.g., 9-11]. Additional designations are used that reflect lithotype for third- and fourth-rank names, such as "ejecta" [12].

Terrestrial lithostratigraphic unit rankings of higher orders as shown in Table 1 are constructed where the stratigraphic sequences are defined and varied for a considerable period in a particular regional setting. If the basic unit, the formation, is closely related to one or more other formations, they may be assigned to a group. A supergroup may arise from a collection of groups and individual formations. For example, the Precambrian Grand Canyon Supergroup in Arizona includes the Unkar and Chuar Groups along with the Nankoweap and Sixtymile Formations. In turn, the supergroup is overlain by another 16 formations that occur in the Grand Canyon, several of which comprise the Tonto and Supai Groups [13]. Thus, not every formation belongs to a group or a supergroup and not every group belongs to a supergroup. Also, formations may or may not include members and other subunits.

In similar fashion, the grouping of units on Mars and other planetary surfaces should be performed judiciously; this includes not grouping units (and groups of lower order) in cases where geologic, morphologic, and/or geographic associations with other units appear to be weak, coincidental, or non-existent. In other words, one should place a unit into a group (or group into a higher order group) only when there is a clear fit. In addition, a unit may be located within a particular geographic zone or province but may be so geologically distinct from the other units in the group that it should be excluded.

Given this understanding that not all units need to be included in a hierarchy, we suggest the following scheme based primarily on geographic and geomorphic associations, as summarized in Table 1. (1) The first geographic level is the "zone," which is the broadest grouping used in global mapping. These may include for Mars highland, lowland, transition (highland/lowland boundary), polar, basin, rise (volcanic), and ubiquitous (including scattered craters and volcanoes, etc.) zones. (2) The second level—provinces—would include subdivisions of the zones, such as individual plains, poles, basins, and rises. These would use applicable geographic names (e.g., Amazonis, Tharsis, and Borealis provinces, as used in [8]). (3) The third-level rank would consist of a geographic locality. (4, 5) The fourth and fifth levels would each include either a geographic feature or stratigraphic position.

Unit naming scheme: Scale is a major factor in how units are identified and named. Thus, unit names should be approached consistently with the scale-dependent rankings in Table 1. Based on this premise, we make the following recommendations for global, regional, and local unit names (see Table 2 for examples):

Global units (<1:15M scale): In previous global maps, unit names either have [7] or have not [14] included geographic features. The inclusion of units based on local features greatly increases the number of map units and thus complicates the map. For our global map, we are using the simpler approach in which unit names and symbols consist of the unit's zone and either or both a morphologic (or other) identifier, and a stratigraphic position [3]. Given our preliminary mapping results, we anticipate that we will complete our global map of Mars at 1:20M scale with ~40 map units [3].

Regional units (1:2M to 1:15M): These follow largely the scheme used in [8]. The units are grouped into provinces and named for a related or nearby geographic locality and optionally a definitive feature type or stratigraphic position. The unit names do not include province names, but the province is indicated by a small-cap letter.

Local units (>1:2M): These are similar to regional units but ignore the province designation, because the majority of units occur within a province and thus can be ignored (with the exception of maps that straddle province boundaries, which would require the use of province designators in unit symbols).

Regional- and local-scale maps might include some units of higher order, such as global-scale units, when such are not subdivided.

Remaining work for the map product: We anticipate completing our Mars global geologic map for review by the Fall of 2011, which includes following the latest submission guidelines and, for the GIS product, organizing mapping layers and creating metadata [15].

References: [1] Tanaka K.L. et al. (2007) *7th Intl. Conf. Mars* Abs. #3143. [2] Tanaka K.L. et al. (2008) *LPSC XXXIX,* Abs. #2130. [3] Tanaka K.L. et al. (2010) *in* Bleamaster et al. (eds.), *Abs. Ann Mtg. Planet Geol. Mappers, San Antonio, TX, 2009, NASA/CP—2010-216680,* p. 41-42. [4] Werner S.C. et al. (submitted) *Planet. Space Sci.* [5] Tanaka K.L. (1986) *JGR 91, suppl.,* E139-158. [6] Hartmann W.K., and Neukum G. (2001) *Space Sci. Rev., 96,* 165-194. [7] Scott D.H. et al. (1986-87) *USGS Maps I-1802A-C.* [8] Tanaka K.L. et al. (2005) *USGS SIM-2888*. [9] Chapman M.G. and Tanaka K.L. (1993) *USGS Map I-2294*. [10] Chuang F.C. and Crown D.A. (2009) *USGS SIM-3079*. [11] Dohm J.M. et al. (2001) *USGS Map I-2650*. [12] McGill G.E. (2005) *USGS Map I-2811*. [13] Beus S.S. and Morales M. (1990) *Grand Canyon Geology,* Oxford U. Press, NY. [14] Scott D.H. and Carr M.H. (1978) *USGS Map I-1803*. [15] Tanaka K.L. et al. (2010) *in* Bleamaster et al. (eds.), *Abs. Ann Mtg. Planet Geol. Mappers, San Antonio, TX, 2009, NASA/CP—2010-216680, Appendix,* 21 p. [16] The North American Commission on Stratigraphic Nomenclature (2005) *Amer. Assoc. Petrol. Geol. Bull., 89,* 1547-1591.

Table 1. Categories and ranks of terrestrial lithostratigraphic units and of Mars map units until now as well as proposed herein.

Lithostratigraphic [16]	**Mars maps** [e.g., 7-12]	**Proposed here (example(s))**
Supergroup	Terrain, Region	Zone (lowland zone)
Group	Assemblage, System, Province, Material(s), Deposits	Province (Borealis province)
Formation	Formation, Unit, Material, Deposits, Other	Locality (Planum Boreum)
Member (or Lens, or Tongue)	Member, Unit, Deposits	Feature/Position (bright, ridged/1, 2)
Bed(s) or Flow(s)		Feature/Position (layered/1, 2 or a, b)

Table 2. Proposed unit naming schemes for geologic maps of Mars at various scales.

Map scale	Unit name scheme (unit name examples)
Global, <1:15M	Zone and feature[1] and/or position[1] (polar dune unit, basin 4 unit, transition knobby 2 unit)
Regional, 1:2M-1:15M	Province[2], locality, and feature[1] or position[1] (Simud Valles unit, Planum Boreum cavi unit, Planum Boreum 1 unit)
Local, >1:2M	Locality, primary[1] and secondary[1] feature or position feature/position (Olympia Undae unit, Scandia Colles 2 unit, Amazonis Planitia 1 flow unit, Alba Mons 3b unit)

[1]If needed.

[2]Highest rank noted; in unit symbol but not in unit name.