**GEOLOGY OF THE SOUTHERN UTOPIA PLANITIA HIGHLAND-LOWLAND BOUNDARY PLAIN: SECOND YEAR RESULTS AND THIRD YEAR PLAN.** J. A. Skinner, Jr., K. L. Tanaka, and T. M. Hare. Astrogeology Team, U. S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ 86001 (jskinner@usgs.gov).

**Introduction:** The southern Utopia highland-lowland boundary (HLB) extends >1500 km westward from Hyblaeus Dorsa to the topographic saddle that separates Isidis and Utopia Planitiae. It contains bench-like platforms that contain depressions, pitted cones (some organized into arcuate chains and thumbprint terrain), isolated domes, buried circular depressions, ring fractures, polygonal fractures, and other locally- to regionally-dispersed landforms [1-2]. The objective of this map project is to clarify the geologic evolution of the southern Utopia Planitia HLB by identifying the geologic, structural, and stratigraphic relationships of surface materials in MTMs 10237, 15237, 20237, 10242, 15242, 20242, 10247, 15247, and 20247.

The project was originally awarded in April, 2007 and is in its final year of support. Mapping is on-schedule and formal map submission will occur by December, 2009, with finalization anticipated by April, 2010. Herein, we (1) review specifics regarding mapping data and methods, (2) present nomenclature requests that we feel will assist with unit descriptions, (3) describe Year 2 mapping and science accomplishments, and (4) outline Year 3 technical and managerial approaches for finalizing the geologic map.

**Datasets and methods.** The base map is a THEMIS daytime IR mosaic (100 m/px). Though the temptation is to integrate all available data, we find that selected data sets provide the most critical information for production of a geologic map at 1:1M scale. In particular, THEMIS VIS images (viewed via internet hotlink), MOLA topography and derivatives (viewed as layers), and CTX images (viewed as layers), are the most helpful in describing geologic units and delineating their temporal relationships. We have used other datasets intermittently.

Mapping layers are co-registered with global datasets in a GIS, which also serves as the digital mapping environment. We find that map scales ranging from 1:200,000 to 1:300,000 are optimal for geologic mapping on the THEMIS daytime IR base map. We delineate surface features >500 meters in diameter (0.5 mm at map scale). We digitally stream vector linework using a digital map tablet with a vertex spacing of 250 meters. Line attributes are assigned on-the-fly. Unit polygons are built periodically from digitized contacts and iteratively attributed and revised. In order to preserve locational detail, vector layers will only be smoothed during final stages of map edit.

**Nomenclature.** Planetary names objectively (i.e., non-genetically) identify features of spatial and/or topographic uniqueness in order to provide context for consistent description. To assist in unit delineation and description for this map region, we recently submitted a nomenclature request to the IAU to uniquely identify the region located between Nepenthes Mensae and Amenthes Cavi (**Fig. 1**). We proposed a name for the 275-km-wide, gently-sloping plain in order to highlight its high-standing character, relative to the smooth plain located north of Amenthes Cavi. We also requested names for three impact craters in Nepenthes Mensae and Planum (**Fig. 1**), each of which have unique ejecta and rim morphologies.

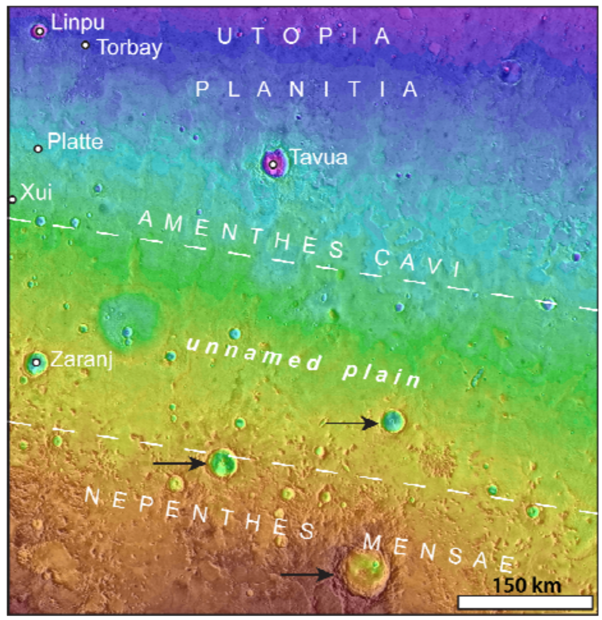


**Figure 1.** Subset of the map region showing existing and proposed physiographic features. The approximate boundary of the unnamed plain is defined by hachured lines. Black arrows identify unnamed craters for which we requested names. White dots show named craters.

**Year 2 Accomplishments.** During Year 2, we completed unit mapping, began stratigraphic analysis, and submitted deliverable components, as outlined in the original proposal. Below, we outline details regarding the current status of geologic mapping.

*Mapping:* Year 1 was devoted to identifying Amazonian and Hesperian geologic units that are located in the northern parts of the map region [1]. Year 2 was similarly devoted to identifying Hesperian and Noachian geologic units that are located in the central and southern parts of the map region. These units constitute the areal bulk of the map region and make up the knobby terrains of Nepenthes Mensae (3 units), the undulating plains of the proposed plain (3 units), and the smooth plains that line Amenthes Cavi (2 units). With the Amazonian units, we currently identify 10 non-crater geologic units within the map region.

Impact craters show widespread and diverse morphologies within the map region, necessitating a more detailed mapping approach than employed in previous geologic maps. Morphologic complexity of crater materials can implicate strength and/or volatile content characteristics of target rocks and strata [3-4]. Because impact cratering appears to be a fundamental aspect of the regional geologic history, we subdivide crater units into facies, using the approaches employed in pre-Apollo lunar geologic maps [e.g., 5]. We use an undivided unit (AHc) for impact craters with rim diameters ≥3 and <15 km throughout the map region. Noachian craters in this diameter range are heavily-eroded and are identified by line symbol only. There are 21 impact craters with rims ≥15, which are generally considered "complex" impact craters [4]. Of these, 12 craters have mappable facies, including distal ejecta, proximal ejecta, rim, wall, floor, and peak materials. The remaining 9 complex craters are eroded and identified either as rim material or by symbol. Crater material for impacts with rim diameters <3 km are not mapped as separate geologic units.

*Stratigraphy:* We tabulated and quality-checked all primary impact craters that have rim diameters ≥1 km throughout the map region, for a total of 1987. Crater counts have not been completed to date due to the ongoing iteration of geologic units, though past investigations provide context for regional stratigraphy [1-2, 6]. Original work plans included subdivision of tabulated craters into morphologic states (i.e., "preserved" versus "eroded"), an approach we now find subjective and ambiguous to the point of irrelevance. As a result, we intend to present crater counts based on total populations and use stratigraphic relationships and past studies to assist in assigning temporal relationships. This approach, though more straight-forward and repeatable, will require a more detailed discussion of age determinations in the map text.

*Deliverable:* A strong approach to a geologic mapping project is the presentation of map-based scientific analysis. The effect of deliverable preparation is threefold. First, it promotes review by the scientific community over the course of the project, allowing for refinement of approach, techniques, and hypotheses. Second, it provides a means to publish preferred hypotheses outside the more rigorous objectivism required in USGS geologic maps. Third, it allows for considerable slimming of the geologic map text so that hypotheses can be referenced rather than presented in full.

We prepared two science deliverables during Year 2. We presented an abstract for LPSC in March, 2009, which outlines the characteristics and formational scenarios for the lobate materials of the circum-Amenthes Cavi materials [7]. In addition, we published an article in a terrestrial journal, which reviews the standing hypotheses for extraterrestrial mud volcanism [8]. The latter contains a detailed description of the map region and explores the possibility of both violent eruption and quiescent extrusion of fluidized sediment as a means to form the Amenthes Cavi and associated mounds, cones, and smooth and rugged lobate materials.

**Year 3 Work Plan.** In order to maintain the proposed schedule of map production, the Year 3 work plan will include completion of map components and preparation of final deliverable products. We note that some technical aspects of our finalized map will deviate from previously-published standards. For example, we envision revised approaches to presenting the correlation of map units (COMU) and description of map units (DOMU). We will use physiographic divisions in the COMU based on hemisphere-scale work by [1] and may include "un-mapped" units in the COMU for reference. In addition, we find that hierarchical unit groupings (i.e., the Amenthes Formation) are useful to provide strength to geologic interpretation, similar to the approach in *Viking*-based geologic maps [9].

Geologic maps fundamentally assist with interpretation and their utility can be tied to succinct and streamlined presentation of map information. As such, we will employ a minimalist approach so that we avoid the cluttering effect commonly associated with superfluous map text, figures, and tables. For example, our DOMU will describe geologic units only as they appear in the THEMIS daytime IR base map. Unit characteristics as observed in supplemental datasets will be tabulated and included in the map pamphlet. Moreover, the map sheet will include only a "Summary of Geologic History" along with appropriate references. Our goal is to have the map be a stand-alone product for easy use. An accompanying map pamphlet will contain map details, including rationale, datasets, methods, and tabulated unit characteristics. To supplement, we will submit a topical science letter and geologic summary paper for publication during map review.

**References.** [1] Tanaka *et al.*, (2005) *USGS SIM 2888*, 1:15M scale. [2] Skinner, J.A. Jr. *et al.*, (2007) *Icarus*, *186*, 41-59. [3] Wilhelms, D.E., (1990) in *Planetary Mapping* (R. Greeley and R.M. Batson (eds.)), Cambridge U. Press. [4] Melosh, H.J. (1989), *Impact Cratering: A Geologic Process*, Oxford University Press. [5] Schmidt, H.H. *et al.,* (1967) *USGS I-515*, 1:1M scale. [6] Tanaka, K.L. *et al.*, (2003a) *JGR*, *108*, (E4). [7] Skinner, J.A., Jr., *et al.* (2009), *LPSC XL*, abs. #2459. [8] Skinner and Mazzini, (2009), *JMPG*, in press. [9] Greeley, R. and Guest, J.E., (1987) *USGS I-1802-B*, 1:15M scale.