GEOLOGICAL MAPPING OF GANYMEDE. G. Wesley Patterson[1], James W. Head[1], Geoffrey C. Collins[2], Robert T. Pappalardo[3], Louise M. Prockter[4], and Baerbel K. Lucchitta[5]. [1]Department of Geological Sciences, Brown University, Providence, RI 02912 (Gerald_Patterson@brown.edu); [2]Wheaton College, Norton, MA 02766, [3]LASP, University of Colorado, Boulder, CO 80309; [4]Applied Physics Laboratory, Laurel, MD 20723; [5]USGS, Flagstaff, AZ, 86002.

Introduction: The Galilean satellites represent a series of bodies that contrast distinctly in their physical properties, surface geology, and thermal evolution [1-4]. Their conditions of formation are very likely linked to the early history of the proto-Jovian nebula, with their disparate characteristics related to the radially varying conditions in the earliest period of their formation [5,6]. The reasons for these differences in geological evolution represent one of the most fundamental problems in comparative planetology [6,7]. Why are the surfaces of Ganymede and Callisto so strikingly different? What are the factors involved in their geological evolution? What roles do internal (e.g., possible presence of liquid-water ocean at depth) and external forces (e.g., tidal interactions) play in explaining the differences between Ganymede and Callisto?

One of the most basic constraints on these questions is the geological record of Ganymede as revealed in imaging and other remote sensing data. To that end, we are compiling a global geologic map of Ganymede (at the 1:15M scale) that will represent the most recent understanding of the satellite on the basis of Galileo Mission data. This contribution builds on important previous accomplishments in the study of Ganymede [8-12] and seeks to further clarify: 1) the major geological processes operating on Ganymede, 2) the characteristics of the geological units comprising its surface, 3) the stratigraphic relationships of geological units and structures, 4) the geological history inferred from these relationships, 5) the crater size-frequency distributions on key geological units and structures, and 6) the cratering chronology of Ganymede, which can be used to compare to other Solar System bodies. Here we summarize our progress toward the completion of this global mapping project.

Discussion: The Voyager mission provided important information about the nature of the surface of Ganymede at moderate resolution and these data were used to subdivide the surface into two major terrain types (dark and bright terrain), define the major geologic structures on the satellite, define a series of geologic units, and produce geologic maps (e.g., [13-15]). The Galileo mission provided a host of new data (high-resolution monochromatic, color, and stereo imagery, polarimetry, near-infrared spectral imagery, etc.) and the first task we undertook in developing a global geologic map of Ganymede was to reassess the units identified at Voyager resolution using this new data [16, 17]. The result of this reassessment was a revised Description Of Map Units (DOMU) in which the units are divided into five terrain types: 1) bright, 2) dark, 3) reticulate, 4) palimpsest, and 5) crater material. We are using this revised DOMU to produce a preliminary global geologic map, a portion of which can be seen in Figure 1.

Bright material: This material has been subdivided into four units: grooved, subdued, irregular, and undivided. The *grooved unit* is arranged in domains characterized by parallel, roughly evenly spaced grooves and ridges oriented in a single dominant direction. The *subdued unit* is similar to the grooved unit but appears smooth or finely grooved at Galileo and/or Voyager resolution except where secondary craters and crater chains are superposed. The *irregular unit* is similar to the subdued unit but contains isolated grooves with no preferred orientation. The *undivided unit* represents all materials of sufficiently low resolution that morphological properties and/or age relationships cannot be determined.

We follow Shoemaker et al. [9] in using structure as a distinguishing characteristic for bright material here because of the scale at which we are mapping. While at high-resolution the faults which constitute the grooved terrain are clearly visible and could be mapped individually, at the regional scale such a map would be incomprehensible due to the density of features [9,16].

Dark material: This material has been subdivided into three units: cratered, lineated, and undivided. The *cratered unit* represents large areas of low albedo material with moderate to high crater density commonly occurring as polygons bounded by bright units. The *lineated unit* is similar in character to the bright grooved unit but with lower albedo and depressions tending to be more sinuous and shallower. The *undivided unit* represents all materials of sufficiently low resolution that their material properties cannot be determined. This also may include irregularly shaped large patches and small slivers of low albedo material interspersed within light terrain of indistinct morphology or areas too small to be identified by morphologic criteria other than albedo.

The inclusion of structure as a distinguishing characteristic for the lineated unit is predicated on the scale at which we are mapping (as with the bright material units). However, furrows, which were previously included as a distinguishing characteristic of dark terrain units, are being mapped as separate structures [17].

Reticulate material: This terrain consists of a single unit. It is often associated with and surrounded by bright grooved, bright subdued, and/or dark lineated units but can be distinguished from them by its variable albedo and presence of grooves with two dominant directions (typically orthogonal to each other). Previous maps (e.g., [13,14]) have separated this terrain into bright and dark units based on albedo and associated them with bright and dark terrains respectively. We find differences in albedo for this terrain to be highly variable and inhomogeneous on a local scale and have therefore combined them into a single unit and designate it as a material separate from both bright and dark materials.

Palimpsest material: This material consists of two units: palimpsests and palimpsest interior plains. The *palimpsest unit* is characterized by flat, generally circular to elliptical structures occurring predominately (but not exclusively) on dark terrain units. These structures lack rims but can have internal, concentric ridges. The *palimpsest interior plains unit* is characterized by smooth, circular to subcircular patches of high albedo material commonly found at or near the center of palimpsests.

Previous mappers (e.g., [13-15]) chose to subdivide palimpsests into three stratigraphic units based on shape (from circular to irregular), apparent degradation, and the presence of specific structures. However, it remains unclear whether or not irregularly shaped bright patches are indeed palimpsests as they appear to lack features identified as characteristic of this terrain type [18]. Furthermore, the interpretation of degradation state can be subject to resolution and lighting conditions. This has led us to combine these units into a single palimpsest unit in which structures are superposed.

Crater material: This terrain consists of seven units: bright craters, partly degraded craters, degraded craters, secondary craters, dark crater material, basin rugged material, and basin smooth material. The first three units separate craters into a stratigraphic sequence (from youngest to oldest respectively) based on degradation state, which we feel can be more clearly determined then for palimpsests. The secondary crater unit is characterized by fields of uniform, small pits surrounding large bright craters, partly degraded craters, and some palimpsests. Dark crater material appears to be predominately associated with bright craters and forms dark patches on their floors or rims. The basin material units are used to define the prominant Gilgamesh basin.

Preliminary map: Using the revised DOMU described above, we are in the process of compiling the global geologic map. Our procedure for accomplishing this task is for at least two researchers to concurrently map in 60˚x60˚ quadrangles (Fig. 1). Each quadrangle is mapped independently and, after completion, they are compared for discrepancies in the locations of terrain types and boundaries. These discrepancies are discussed and reconciled to produce a single preliminary quadrangle (as shown in Fig. 1). We have completed numerous quadrangles, spanning from -30˚ to 30˚ lat. and 115˚ to 295˚ lon. and they cover all terrain types described except basin materials and span a wide range of resolutions and lighting conditions.

We are proceeding with this mapping scheme for the entire imaged surface of Ganymede. Upon completion of the global map, we will review the results with all participating researchers to discuss and reconcile any other discrepancies or issues before finalizing the map.

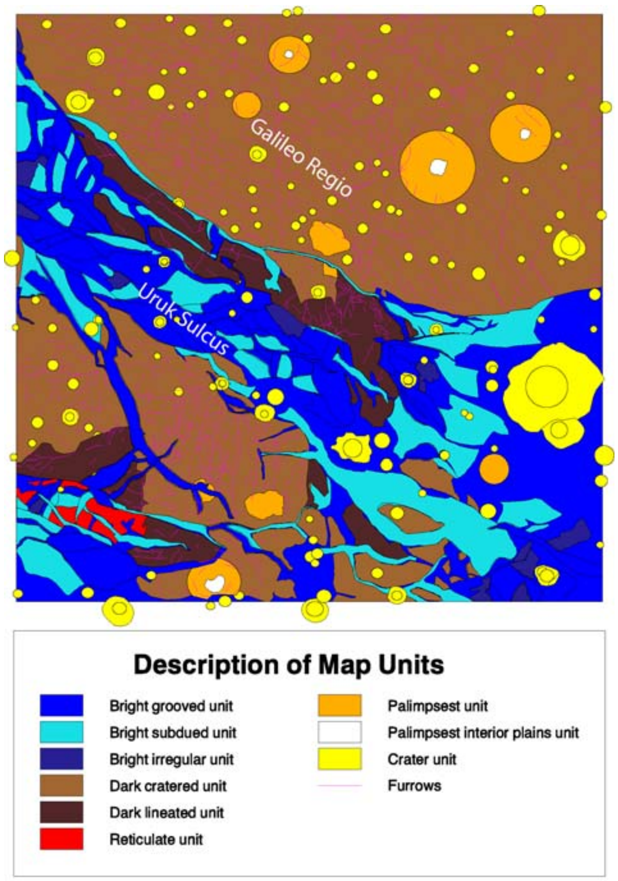

Fig. 1. Preliminary geologic map of Uruk sulcus region (-30 to 30˚ lat. and 115˚ to 175˚ lon.) utilizing revised DOMU presented here.

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