A GLOBAL GEOLOGIC MAP 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]Jet Propulsion Laboratory, Pasadena, CA, 91109, [4]Applied Physics Laboratory, Laurel, MD, 20723, [5]USGS, Flagstaff, AZ, 86001.

Introduction: We have compiled a global geological map of Ganymede that represents the most recent understanding of the satellite on the basis of Galileo mission results. This contribution builds on important previous accomplishments in the study of Ganymede [e.g., 1-8], and has helped to further determine: 1) the major geological processes operating on Ganymede, 2) the characteristics of the geological units making up its surface, 3) the stratigraphic relationships of geological units and structures, 4) the geological history inferred from these relationships, and 5) the crater density distributions on key geological units. The post-Galileo global geological map of Ganymede will therefore help to provide constraints on models for the formation and evolution of Ganymede and potentially the other the Galilean satellites.

Material units:

Dark material: Dark material (Fig. 1a) comprises ~1/3 of Ganymede's surface and is subdivided into three units for the global geologic map: A cratered unit (**dc**), a lineated unit (**dl**), and an undivided unit (**d**). This material has been heavily modified via impact processes (palimpsests, craters, basins, and related furrows), sublimation, mass wasting, and tectonism. Measured crater densities suggest that dark material units are the oldest surficial units on the satellite [7-10]. Dark material is heterogeneous in albedo at decameter scales, probably resulting from thermally driven segregation of ice and non-ice surface components [11]. Galileo high resolution images suggest that the dark material is composed of a relatively thin dark deposit overlying brighter icy material, and that it has been modified by surface processes such as sublimation, mass wasting, ejecta blanketing, and tectonism [6, 12]. The darkest deposits appear to occur within local topographic lows, suggesting that downslope movement of the dark non-ice component may play an important role in albedo segregation [13].

Light material: Light material (Fig. 1b) covers the other ~2/3 of Ganymede's surface and is subdivided into four units: A grooved unit (**lg**), a subdued unit (**ls**), an irregular unit (**li**), and an undivided unit (**l**). Light material forms swaths that cross-cut the older dark terrain and contain polygons 10s to 100s of kilometers wide, forming an intricate patchwork across the surface. Units within light material have crater densities approximately half that of dark materials, suggesting a nominal age of ~2 Gyr [9,10]. However, large uncertainties in the impactor flux through time imply large errors associated with this determination (i.e., from ~400 Myr to >4 Gyr in age) [7-9]. Light material is primarily characterized by the density and orientation of structural grooves that exist within a given polygon. Light materials are interpreted to form from dark material via extensional tectonism, likely intiated along preexisting fractures (such as furrows). This results in the development of horst and graben or normal faulted tilt-blocks. The formation of these features sheds the dark veneer that covers dark material units by downslope movement, exposing a brighter, more ice-rich substrate. Some icy volcanism may also be associated with the formation of grooved material [14].

Reticulate terrain: This terrain (Fig. 1c) consists of a single unit (**r**). 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 near-orthogonal to each other). Reticulate terrain appears to represent dark and light material that has been modified by the formation of orthogonal sets of grooves. It has been suggested that the formation of reticulate terrain may be the result of subsequent episodes of extensional tectonism [4,7], or of block rotation within a distributed shear zone [15].

Impact material: Impact material is divided into three subunits: Crater (Fig. 1d), Palimpsest, and Basin material. These divisions are based on crater diameter, relative age, and differences in morphology.

Crater material is interpreted to be the result of impact into a relatively thick, brittle lithosphere and is further subdivided based on the presence of rays, ejecta, and the degradation state of the crater rim into degraded craters (**c_1**), partially degraded craters (**c_2**), and fresh craters (**c_3**). Craters that cannot be categorized in this manner, most often due to resolution effects, constitute a fourth crater material unit: unclassified craters (**cu**).

Palimpsest material is interpreted to be a result of impact into a thinner brittle layer overlying a more ductile ice and is subdivided into four units: ancient palimpsests (**p_1**), young palimpsests (**p_2**), unclassified palimpsests (**pu**), and palimpsest interior plains (**pi**). The first two are categorized based on their crosscutting relationships with light materials, the third includes all other palimpsests, and the last represents the interior deposits of some palimpsests.

Basin material represents units describing the ejecta from Gilgamesh basin and is subdivided into two units: Basin rugged material (**br**) and basin smooth material (**bs**).

Stratigraphy: As part of our global mapping effort, we have identified ~4000 craters >10km in diameter across the surface of Ganymede. This dataset has enabled us to calculate crater densities (on a global-scale) for each of the material units we have defined (Table 1). It has also provided a valuable link to previous regional estimates of crater densities calculated for various material types utilizing counting areas 10 to 100 times smaller [7,16].

Table 1.

	10 km[a]	20 km	30 km	Area (x 10^6 km^2)
<u>Light</u>				
grooved	39±2	14±1	8±1	9.29
	(44±3)[b]	(14±2)		(5.71)
irregular	30±4	13±3	6±2	1.94
	(20±5)	(5±2)		(0.992)
subdued	42±2	18±1	9±1	8.24
	(39±3)	(15±2)		(4.90)
<u>Dark</u>				
cratered	85±2	32±1	15±1	21.9
	(97±2)	(34±1)		(16.3)
lineated	67±8	19±4	8±3	1.06
	(69±8)	(20±4)		(1.01)
<u>Reticulate</u>				
reticulate	39±12	18±8	4±4	0.28
	(39±12)	(18±8)		(0.28)
<u>Impact</u>				
Palimpsest	61±7	23±4		1.37
Basin	19±5	11±4		0.80

[a] Number of craters ≥ the quoted diameter, normalized to 10^6 km^2.

[b] Numbers in parenthesis indicate values calculated from image data at resolutions ≤ 1.5 km/pixel.

References: [1] Guest et al., USGS Map I-1934, 1988; [2] Wilhelms, USGS Map I-2242, 1997; [3] Lucchitta et al., USGS Map I-2289, 1992; [4] Lucchitta, Icarus, 44, 481-501, 1980; [5] Pappalardo et al., Icarus, 135, 276-302, 1998; [6] Prockter et al., Icarus, 135, 317-344, 1998; [7] Shoemaker et al., Sats. of Jupiter, 435, 1982; [8] Murchie et al., JGR, 91, E222-E238, 1986; [9] Zahnle et al., Icarus 163, 263-289, 2003; [10] Schenk et al., in Jupiter, 427-456, 2004; [11] Spencer, Icarus 69, 297-313, 1987; [12] Prockter et al., JGR 105, 22,519-22,540, 2000; [13] Oberst et al., Icarus 140, 283-293, 1999; [14] Schenk et al., Nature 410, 57-60, 2001; [15] Murchie and Head, JGR 93, 8795-8824, 1988; [16] Murchie et al., Icarus 81, 271-297, 1989.

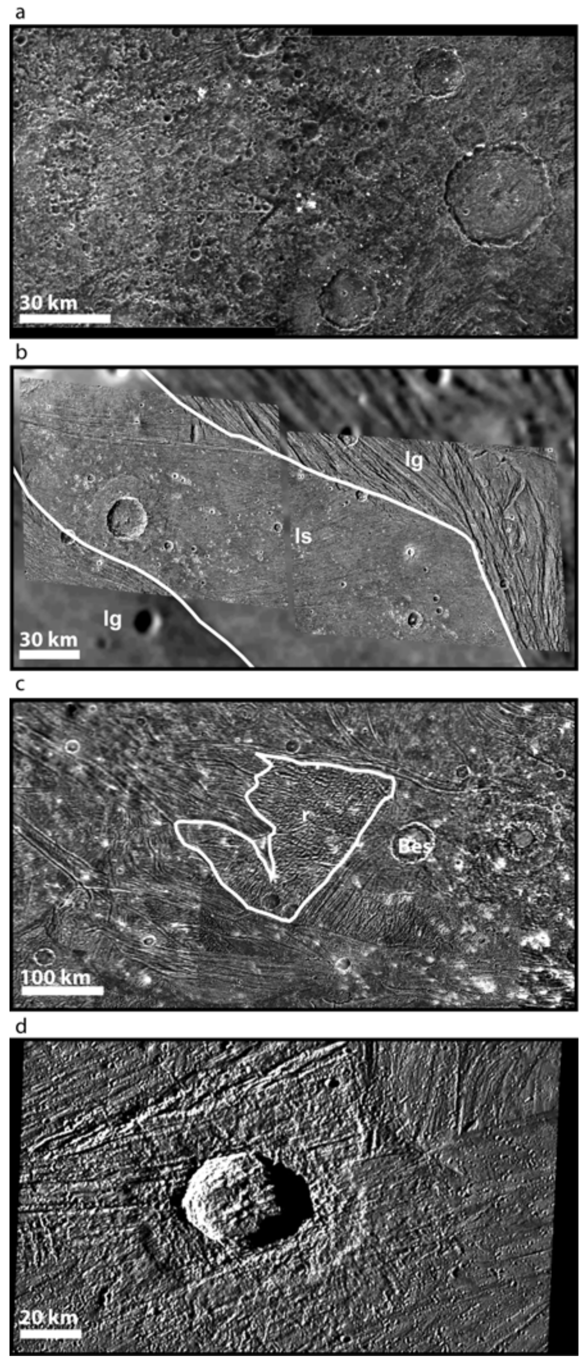

Fig. 1. Type localities for various units in the global geologic map of Ganymede. (a) Dark cratered material [**dc**], located at ~15ºS, 337º in Nicholson Regio and imaged during the G28 encounter at 120 m/pixel. (b) Light grooved [**lg**] and subdued [**ls**] units, located at ~16ºS, 309º within Harpagia Sulcus, east of the prominent crater Enkidu and imaged during the G28 encounter at 160 m/pixel. (c) Reticulate terrain [**r**], located at ~32ºS, 182º in the Sippur Sulcus region, northwest of the prominent fresh crater Osiris and imaged during the G8 encounter at 172 m/pixel. (d) Fresh crater material [$\mathbf{c_3}$], located at ~62ºN, 12º northeast of Perrine Regio and north of Aquarius Sulcus (Achelous crater) and imaged during the G7 encounter at 191 m/pixel.