NASA/USGS Planetary Geologic Mapping Program

Guidelines

from Reno, Nevada, Meeting in July 1996.

Following are guidelines generated during our recent meeting in Reno.
The letter symbols for map units will follow a standard sequence.

Very Important Information Between the Stars!!!

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Standard Sequence Is As Follows:

major unit type --> geographic modifier --> descriptive modifier --> numerical or letter modifier (essentially members). All of these are optional except the major unit type; thus it is OK, for example, to use t for undifferentiated tessera materials, fm for mottled flow materials, etc. The geographic modifier may be upper case. It turns out that this is OK with the USGS as long as the geographic modifier does not come first in the sequence; leading upper case letters are reserved for accepted formal time- stratigraphic names (such has H for Hesperian on Mars), and no such system exists for Venus at present. All other letters should be lower case. If used, the letter or number modifier at the end of the sequence will likely be subscripted on the published map, as has been done on a number of recent Mars maps for members of formations. It is possible that the upper case geographical letters also will be subscripted, although it is not clear at present if this will be esthetically pleasing.

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Specific Examples

1. Regional plains materials (pr) -- these are the areally extensive plains present in most quadrangles, and dominant in many. The governing criterion is regional persistence, not relative abundance in a given quadrangle. If a mapper is in doubt about the continuity of a plains unit over a wide area, the symbol "p" should be used rather than "pr" (see below). Acceptable descriptive modifiers include: undifferentiated, variegated, lineated, ridged, homogeneous, mottled. Modifiers to avoid include: smooth, rough, bright, dark, deformed, fractured. In an earlier set of guidelines, we recommended that letters be used to indicate fine divisions (at the member level) rather than numbers. The use of numbers for an age sequence of regionally extensive units is risky because the oldest member (#1) in one quadrangle might correlate with the #2 member in an adjacent quadrangle. Some examples:

   prGh = Guinevere homogeneous regional plains material.
   prm = mottled regional plains material.
   prra = ridged regional plains material, member a.

2. Plains Materials (p) -- plains with more localized occurrences, possibly (but not necessarily) associated with

fields of cones or shields, coronae, or small edifices. The use of the term "shield plains" is acceptable, but must be explained in the DOMU because many of the volcanic constructs in the plains may be better described as cones, domes, etc. Or one could use the term "edifice plains" to avoid this extra explanation. Numbers implying an age sequence may be used to designate members for these more local units. Some examples:

pRvb = Russalka variegated plains material, member b.
pHh3 = Heng-O homogeneous plains material, member 3 (clearly implying that this member is younger than members 1 and 2).

3. Tessera materials (t) -- materials in terrain characterized by two or more non-parallel ridge or linear sets. This terminology is broad, given all the variations in structural style, but a suite of modifiers may be used to delineate individual material units within this group. Possible modifiers include: undifferentiated, ridged, grooved, lineated. The use of the term "complex ridged terrain" (CRT) is strongly discouraged because large areas of this terrain are more characterized by linears than ridges, and because the word "complex" implies more information than we really know about the material's deformation history. For blocks of tessera extending across two or more quadrangles the use of numbers for members is discouraged. For smaller, isolated blocks of tessera numbers are acceptable because it is not really possible to correlate tessera from one isolated block to another anyway. Examples:

tLr2 = Laima ridged tessera material, member 2.
t = tessera material, undifferentiated for quadrangle-wide undivided tessera.
tu = tessera material, undifferentiated to distinguish undivided tessera materials from other named tessera materials in the quadrangle.

4. Flow materials (f) -- Typically digitate or lobate deposits from a variety of sources. Possible modifiers: digitate, lobate, variegated. Examples:

fTl1 = Tepev Mons lobate flow material, member 1.
f = flow material, undifferentiated.

5. Crater materials (c) -- Floor, wall, rim, central peak, and ejecta deposits of impact craters. For most craters, there is little reason to separate all of these parts, and thus c alone can designate all of them. Flow (not "outflow") materials can be designated by cf. If stratigraphically useful, separate names can be used for individual important craters; thus cfP would be Potanina crater flow material. Likewise, a mapper may designate floor, wall, rim, central peak or ejecta materials for a given crater with different modifiers if deemed important. Thus, for example, cflA, cwA, crA, cpA, ceA for materials of floor, walls, rim, central peak, and ejecta of crater Annia Faustina.

6. Surficial materials or surficial modification -- use stipple or other pattern as an overlay to indicate the presence of surficial materials on top of mappable rock units, or to indicate the presence of surface modification by some process that has not obliterated mappable rock units. An important example would be dark or bright parabolas or halos associated with some impact craters. If these are very extensive, such that stippling will result in cluttering the map, it may prove more practical to include a separate text figure showing their extent.

Partially Unresolved Issues:

1. Prominent belts of ridges, linears, or both -- These are the "ridge belts", "fracture belts", and "deformation belts" of earlier reports. "Fracture belt" and "deformation belt" are not acceptable because they are genetic. Material categories called "materials of ridge belts" or "materials of ridge and linear belts" are acceptable; these would be columns in the correlation chart on the map. Only material units confined to belts would be included within these categories; some materials within belts are so modified by the ridges or linears that their original character is lost and thus they must be designated as "belt materials" of some sort. In contrast, a material that can be traced from surrounding plains into a belt should be designated a plains unit and listed within a plains column on the correlation chart. It is important to map material units within these belts and not just draw lines that enclose the ridges and/or linears. Thus the boundaries of a ridge belt, for example, may or may not coincide with material map unit contacts. Most mappers need not worry about these belts

because almost all of them occur either in the Atalanta/Vinmara area or the Lavinia area.

2. The use of "bright" and "dark" as descriptive terms could be acceptable for local features, such as bright crater floors, dark mantle deposits, or small low-return lava flows. These terms must be avoided in describing any areally extensive deposit, since the definitions are vague. It is OK to use descriptions in the DOMU such as: "radar-dark relative to the planetary average at an incidence angle of 45 degrees".

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Below is the proposed general text to be placed in the margin of all Venus geological maps. This will be edited by the USGS (of course), but we believe that its content will be essentially as presented here. There are a few small changes from the version distributed by Ken Tanaka immediately after the Reno meeting.

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Overview paragraphs to go on every map to summarize the Magellan mission The Magellan spacecraft orbited Venus from August 10, 1990 until it plunged into the Venusian atmosphere on October 12, 1994. Magellan had the objectives of:

1. improving the knowledge of the geological processes, surface properties and geologic history of Venus by analysis of surface radar characteristics, topography and morphology, and
2. improving the knowledge of the geophysics of Venus by analysis of Venusian gravity.

The Magellan spacecraft carried a 12.6-cm radar system to map the surface of Venus. The transmitter and receiver systems were used to collect three data sets:

1. synthetic aperture radar (SAR) images of the surface,
2. passive microwave thermal emission observations, and
3. measurements of the backscattered power at small angles of incidence which were processed to yield altimetric data.

Radar imaging, altimetric, and radiometric mapping of the Venusian surface was done in mission cycles 1, 2 and 3, from September 1990 until September 1992. Ninety-eight percent of the surface was mapped with radar resolution on the order of 120 meters. The SAR observations were projected to a 75-m nominal horizontal resolution, and these full-resolution data comprise the image base used in geologic mapping. The primary polarization mode was horizontal-transmit, horizontal-receive (HH), but additional data for selected areas were collected for the vertical polarization sense. Incidence angles varied between about 20 and 45 degrees.

High resolution Doppler tracking of the spacecraft was done from September 1992 through October 1994 (mission cycles 4,5,6). Some 950 orbits of high- resolution gravity observations were obtained between September 1992 and May 1993 while Magellan was in an elliptical orbit with a periapsis near 175 kilometers and an apoapsis near 8,000 kilometers. An additional 1500 orbits were obtained following orbit- circularization in mid-1993. These data exist as a 75 degree by 75 degree harmonic field.

Radar backscatter power is determined by:

1. the morphology of the surface at a broad range of scales, and
2. the intrinsic reflectivity, or dielectric constant, of the material.

Topography at scales of several meters and larger can produce quasi-specular echoes, with the strength of the return greatest when the local surface is perpendicular to the incident beam. This type of scattering is most important at very small angles of incidence, since natural surfaces generally have few large tilted facets at high angles. The exception is in areas of steep slopes, such as ridges or rift zones, where favorably tilted terrain can produce very bright signatures in the radar image. For most other areas, diffuse echoes from roughness at scales comparable to the radar wavelength are responsible for variations in the SAR return. In either case, the echo strength is also modulated by the reflectivity of the surface material. The density of the upper few wavelengths of the surface can have a significant effect. Low-density layers such as crater ejecta or volcanic ash can absorb the incident energy and produce a lower observed echo. On Venus, there also exists a rapid increase in reflectivity at a certain critical elevation, above which high-dielectric minerals or coatings are thought to be present. This leads to very bright SAR echoes from virtually all areas above that critical elevation.

The measurements of passive thermal emission from Venus, though of much lower spatial resolution than the SAR data, are more sensitive to changes in the dielectric constant of the surface than to roughness. As such, they can be used to augment studies of the surface and to discriminate between roughness and reflectivity effects. Observations of the near-nadir backscatter power, collected using a separate smaller antenna on the spacecraft, were modeled using the Hagfors expression for echoes from gently undulating surfaces to yield estimates of planetary radius, Fresnel reflectivity, and root-mean-square slope. The topography data produced by this technique have horizontal footprint sizes of about 10 km near periapsis, and a vertical resolution on the order of 100 m. The Fresnel reflectivity data provide a comparison to the emissivity maps, and the rms slope parameter is an indicator of the surface tilts which contribute to the quasi-specular scattering component.

Last Update: January 13, 1999
