Fostering digital geologic maps: the digital geologic map of Mercury from the USGS Atlas of Mercury, Geologic Series.

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Introduction

After the Mariner-10 mission to Mercury of the 1970s, the NASA MESSENGER [1] successfully acquired new data in its two fly-bys of December, 2007 and October, 2008. Moreover, the European and Japanese Space Agencies are preparing an upcoming mission to Mercury named BepiColombo [2].

In 1970s the common media for publishing maps was paper. Nowadays, the broad diffusion of computers connected through a network allows scientists to acquire digital data directly, improving their possibilities of analysis and interpretation. In general the amount of details and the extents of a map are limited by the physical size of the media. In the case of paper maps the scale factor is used as the value that limits the details and the extents of the map to a usable physical size of the sheet, so the planetary surfaces have been divided in *quadrangles* taking into account the scale and the actual area covered. In digital systems the limiting factor is the capacity of the storage media. With digital maps, there is no need to scale the units of measurements as computer systems for handling spatially referenced data (commonly referred as Geographical Information Systems – GIS) are able to convert them on the fly allowing to visualize or print a region of the map or the whole map at the preferred scale. Furthermore the information of a digital map can be queried, isolating the features the scientist needs for a particular analysis.

Starting from the nine quadrangles of the 1:5,000,000 USGS Atlas of Mercury, Geologic Series, published in the 1980s, we have produced a single digital geologic map of Mercury suitable to be used with modern computer systems.

Data and Methods

The geologic maps of the Atlas of Mercury, Geologic Series, were produced by various authors between 1980 and 1990 (see Table 1) and published by USGS. In 2000 these maps were converted by USGS from paper to a digital vector format: every map has been digitized and the attributes have been attached to the corresponding geometric feature. The information has been divided into three distinct layers: 1) the geologic units, 2) the geologic structures, and 3) a miscellaneous layer which consists of albedo features, mostly associated with craters related materials. The resulting files were saved in a vector interchange format suitable to be used with GIS, then these digital maps together with their relative metadata have been made available for download from the USGS PIGWAD server at http://webgis.wr.usgs.gov [3].

I. no	Quad.	Authors	Year
I-1660	H-1	Grolier, Boyce	1984
I-1409	H-2	McGill, King	1983
I-1408	H-3	Guest, Greeley	1983
I-1233	H-6	De Hon, Scott, Underwood	1981
I-2048	H-7	King, Scott	1990
I-1199	H-8	Schaber, McCauley	1980
I-1659	H-12	Spudis, Prosser	1984
I-1658	H-11	Trask, Dzurisin	1984
I-2015	H-15	Strom, Malin, Leake	1990

Table 1: Geologic Maps of Mercury published by USGS up to 1990

The nine digital geologic maps provided by USGS were imported into a Geographic Resources Analysis Support System (GRASS) GIS database [4], in Cylindrical projection, using a planetary radius of 2439 km. Every layer passed through two main phases: the editing of the geometry, and the editing of the tabular information attached to the geometry.

As geologic maps are the results of an interpretation of actual data it is common to have mismatches on the border between two or more maps, although these mismatches are small in magnitude so the overall coherence among the maps is guaranteed.

In order to produce a single digital geologic map we had to detect the mismatches and fix them by direct editing, as the fully automatic merging procedures did not solved all the topological problems, and often introduced unwanted artifacts.

We have found three main families of mismatches: 1) a mismatch of position of the features 2) a feature present on one side is not present on the other side and 3) the feature coincides geometrically through the border but it is assigned to a different category. During the merging process all the editing operations were done to reflect as much as possible the original authors' work, as no recent data have been used at this stage.

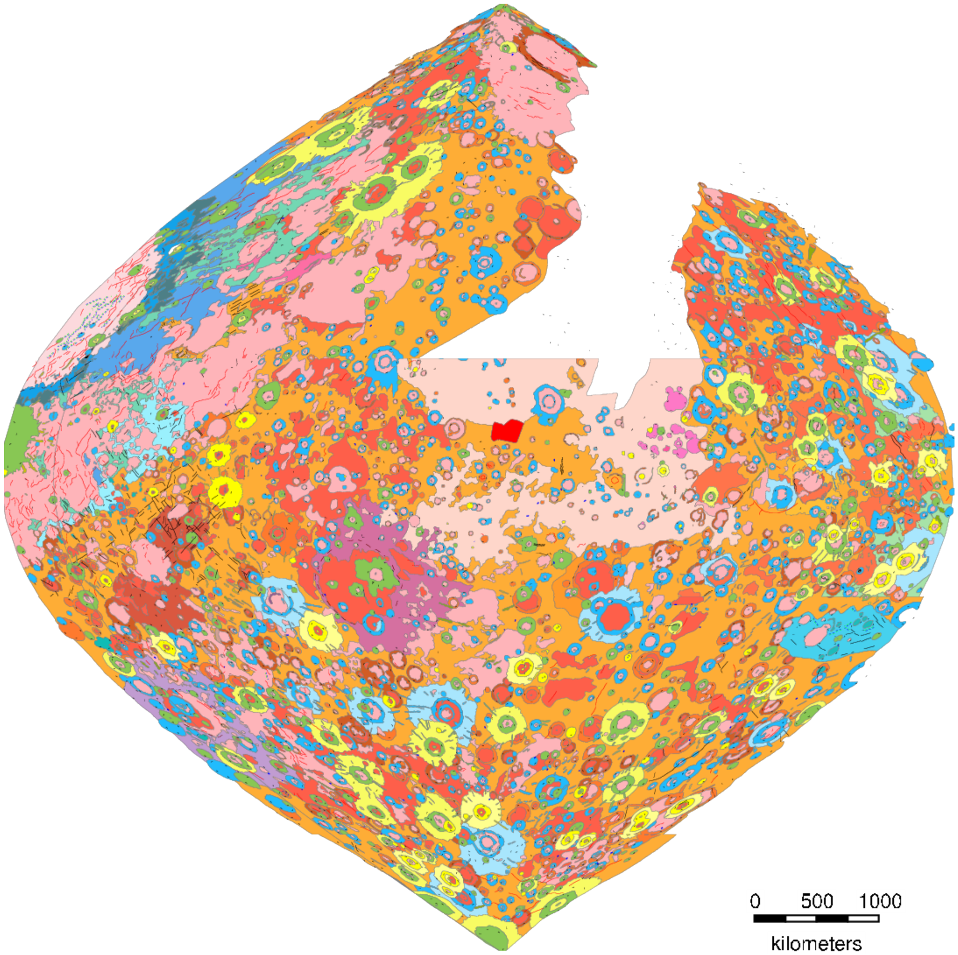

Figure 1: The complete digital geologic map of Mercury from the USGS Atlas of Mercury, Geologic Series. Colors of the units reflect the original paper maps ones and have been added into the digital map as a record of Red/Green/Blue values. Graphic bar scale refers to the center of the projection (see text).

Results and Discussion

Figure 1 shows the results of the merging process, the digital geologic map of Mercury is displayed as geologic units and structures, displayed with a sinusoidal projection centered at 0°N and 95°W.

This single digital geologic map of Mercury offers several advantages over the nine quadrangles. We have a clearer overview of the geologic setting of areas that were falling among several quadrangles. Personalized displays and paper maps can be generated as needed. Features can be located and extracted selectively and used for a specialized investigation. Other data layers as image mosaics or shaded reliefs can be overlayed to the map. As MESSENGER and BepiColombo missions send more accurate and detailed data than Mariner 10, it will be possible to perform a renewal process of the geologic map both by filling unmapped areas and by improving the accuracy and resolution of mapped units, as done for example by [5] who updated the geologic map of Mars, originally based on Viking data, with a newer and more accurate one.

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