Geobrowsers vs. Cartographic Artworks: Virtual Planetary Globes Designed for K–12 Education

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Abstract. Virtual planetary globes provide a new, exciting mean of geographical discoveries on both Earth and other planetary bodies. Photomosaic maps are excellent tools but for K–12 education, they are not self-explanatory maps. To make full use of the virtual globe technology, non-automated cartographic products should complement the high resolution imagery. On planetary maps and virtual globes, the “art” part of cartography seems to be marginalized; however, to create attractive and easy-to-understand virtual maps, graphic arts should have the same importance as the technology and science aspects of cartography.

Keywords: virtual globe, planetary cartography, graphic arts

1. Introduction

Geography has lost its fascination it had for centuries, from the age of discoveries until all white spots had been replaced by actual map content. For students, geography became a spatial database to learn, both in physical and human geography. Recently topography and blind maps gradually lose their central role in teaching geography and teaching concentrated on trends and stories. Maps and the physical geographical features became again exciting places to discover only with the advent of virtual maps and globes (also termed geobrowsers) that can provide an opportunity for the “re-enchantment of geomorphology” (Tooth 2006, Tooth 2012) as they are powerful exploratory learning tools (Schultz et al. 2008).

However, the overlays of these Google maps in which physical geographical features are visible are automatically derived products that lack proper labeling and generalization on various scales. The virtual maps are either well developed vector based city maps and political maps, showing imagined or man-made features; or satellite image mosaics that are hard to interpret, except for very large scale images that show our familiar spatial environment; or topographical overlays that show the topography but without any interpretation. For teaching physical geography, neither is an optimal map, but they allow personal discoveries of any place on Earth, at some locations even from the ground based viewpoints (Streetview). But there is no interpretation or explanation on the physical geographical features; especially at regional or global scale. Most of the information, as in the case of augmented reality applications, concentrate on man-made features.

Virtual globes of planetary surfaces have several advantages over printed maps (Hargitai and Gede 2009).

(1) they can provide a relatively distortion-free view of the entire surface,

(2) they can give more "realistic" views from planetary – spacecraft-based – perspective, and are best suitable for a "whole-planet" perspective

(3) the most abundant objects are craters (Kereszturi 2012a): circular object which can be better visualized throughout the entire planet using distortion free globes, and

(4) much studied polar areas, their extent and context are better visualized.

(5) multilayer technology allows fast comparison of different datasets.

2. Critical analysis of virtual planetary globes

Google provides maps of the Moon and Mars, as complex, multi-scale image mosaics. Google Moon offer visible photomosaic, professional geological chart overlays and shaded relief maps. Google Mars provides color coded shaded relief map, and photomosaics in the infrared and visible specra (the latter is in practice a high-sun albedo map). Google Earth provides additional planetary layers. None of these is suitable for teaching the physical geography of these planetary bodies alone, without further explanations. As the world itself, they are beautiful, but they do need interpretation. Virtual mosaics of planetary surfaces are also very useful in scientific research whose aim is to compare or find various features on a global scale, but can only give preliminary results since the actual image parameters are not published. Its aim in helping scientific research is “to allow planetary scientists to more rapidly browse and locate specific data sets if interest and more easily build and share data within the scientific community” (Hancher et al. 2009) and also helps in the planning of missions with surface activity there (Kereszturi 2012b). Hancher et al. continues: “[it] will also provide an easy platform for public outreach and education efforts, and will easily allow anyone to layer other forms of geo-spatial information on top of planetary data”. Google Earth is therefore an outreach tool and a basic platform that can host other cartographic products. Partly similar, dual goals are formulated by the visualization studio at NASA: „The mission of the Scientific Visualization Studio is to facilitate scientific inquiry and outreach within NASA programs through visualization.” (NASA 2012) This studio produces not only maps but other visually attractive products as well.

Usually various points of interest provide additional details (explanations and close-up images) on particular features, but on a local scale. On a regional and global scale, the features remain enigmatic.

However, with carefully developed methodology or pre-created educational materials, virtual globes can be places where research can be done. For example, users can compare similar landforms, for example barchans, on Google Earth and Google Mars at similar resolution (Tooth 2012). However, these applications are still not maps in the classical sense, only more or less controlled photomosaics. A next phase in developing such geobrowsers would be to create self-explanatory or rather, self-explaining maps – not photomosaics – in all local, regional and global scales. This requires interpretation instead of automated data visualization.

In a study made in the USA, 6th grade students were given paper maps and similar maps in Google Earth and were asked the same questions. The students using paper maps averaged slightly higher than those using Google Earth; but the teacher observed that the exercises were more memorable and fun for the students who used Google Earth (Clagett 2009). Combining the advantages of traditions of “paper-cartography” and attractiveness, interactivity and digital advantages of virtual globes, one can produce maps that are both memorable and fun, and also understandable even for pupils.

Such true maps cannot be expected from Google; they provide the base maps, and cartographers are to produce the actual thematic maps. A graphically very attractive and cartographically excellent terrestrial example is the “Swiss World Atlas Interactive”, a web-based school atlas that complements the already existing printed atlas version (Marty et al. 2009). However even here scalable, vector based labels are inferior to those in the printed edition (cf fig 5. in Marty et al. 2009).

The cooperation of planetology and cartography experts resulted in maps that are not only scientifically correct but also applying the appropriate cartographic visualization principles, giving a nice example of the traditional definition of cartography that is “the science, technology and art of map making”.

3. Planetary Globe Series by ICA

Over the last few years, a set of virtual globes of Mars, the Moon, Venus and Titan – topographic, photomosaic (albedo/radar/IR) and historic maps – has been produced as the extension and continuation of the map series ”Multilingual Maps of Terrestrial Planets and the Moon“ coordinated by the Commission on Planetary Cartography of the International Cartographic Association (ICA) (Shingareva et al. 2005). The goal of this series is to provide easily accessible planetary maps and globes to the general public with detailed nomenclature. Some of the globes are showing topographic data (Mars, Moon, Venus), others radar and IR datasets (Titan), or albedo (photomosaic) (Mars, Venus). The Mars and Moon topographic globes are also used in an educational online application called “Blind Mouse” (Hargitai et al. 2012). These globes were created with individual coloring scheme and individual, non-scalable labeling (“pixel-burned” labels at appropriate size). The Lunar map has been made in Latin-English and Latin-Hungarian versions, and displays several informal basin names. A major difference to NASA maps is that we use “natural” colors, i.e. the color range is limited as compared to the rainbow-colored NASA maps. The topographic globe of Mars uses only yellowish-brownish colors, avoiding both blue (with association to water) and green (with association to vegetation) (Hargitai 2006). Colors range from white (-8 km) to yellow to orange to brown for the mountains. Another project, the production of the bilingual and biscriptal relief map of Venus in Russian and Latin, initially used orange to purple hues in its preliminary versions (Lazarev and Rodionova 2011), but the for the final version Lazarev et al. (2012, personal communication) have “decided to change the colors of the height scale, because violet color on the previous scale appeared not to correspond with Venus' nature”. This version uses brown to orange hues. The choice of colors is important, because it gives the first impression of the map that in turn represents the planetary body. Even if the true colors are not known (as on Venus) or are more or less grayscale hues (as on the Moon), especially in a series, the colors should represent the characteristics of the surface in one way or another. The rainbow colors used in NASA / USGS publications are ideal for showing the most possible topographical details. Even though the same color scheme is use for all planetary bodies, they are not comparable, because the same colors represent different absolute heights and different height bins. The traditional topographical color scheme use in terrestrial map reflects hydrology, vegetation and height in a very complex way, having multiple connotations. For our lunar map we used "dirt"-oranges for representing densely cratered highlands and high elevations at the same time and light blues to represent the lowlands that are volcanic basalt plains at the same time. White, as on Earth, represent the boundaries of these two terrain types. This is of course is just the overall view; some deep craters have the same blue colors as maria, but still, the first view at the map will tell about the dual nature of the Lunar surface (*Figure 1*).

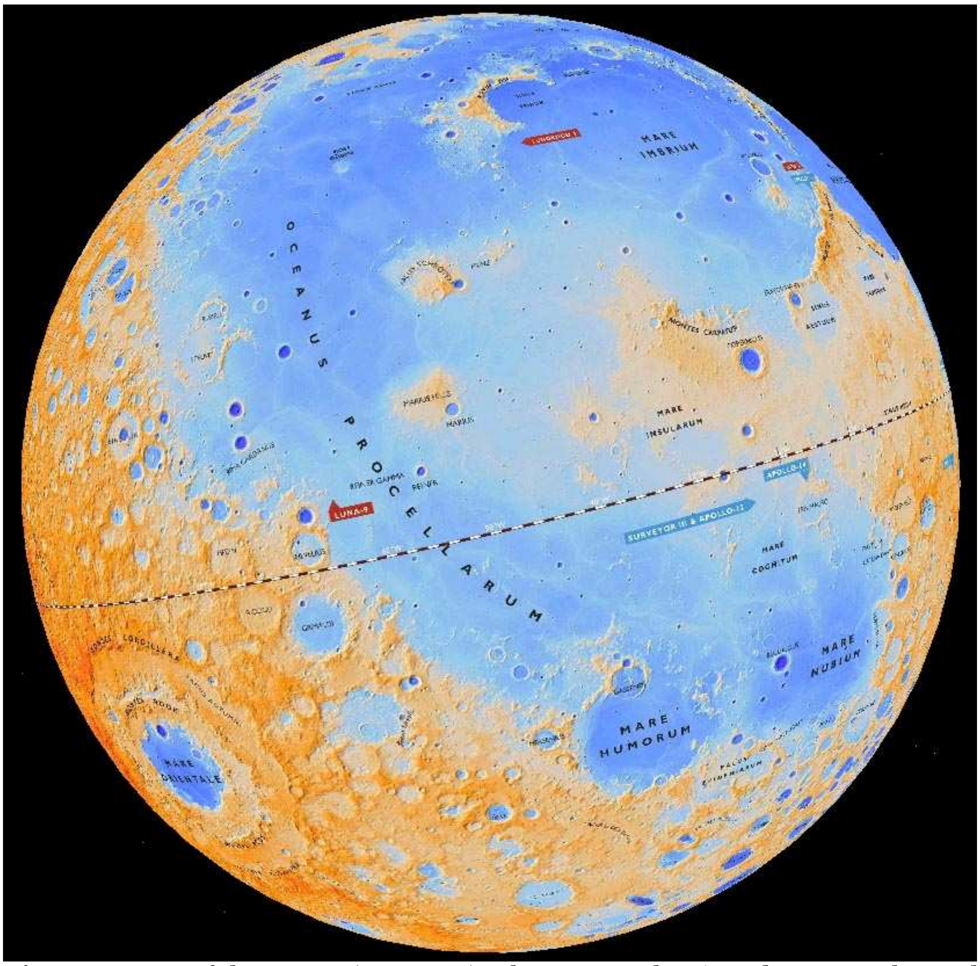

Figure 1. Map of the Moon. (ICA 2012). The map can be viewed as a Google Earth add-on. Labels are non-scalable. LROC data provided courtesy of NASA/GSFC/Arizona State University/DLR http://lroc.sese.asu.edu

The next product in this series will be the virtual globe of Io. Io one of the four Galilean moons of Jupiter. The globe will be produced from three 2-D maps that use the photo-mosaic image of Io as background, which is completed with a geographic grid and toponyms of most named features on the moon. Two maps depict the polar areas in azimuthal equidistant projection while the third one the equatorial regions in Plate-Carée.

These planar maps (designed as printed maps, to be included in the Encyclopedia of Planetary Landforms) (*Figure 2*) are supplemented with a new virtual globe. The content of the globe is the same as of the three photomosaic maps, but the symbols and labels are designed specifically for 3D visualization.

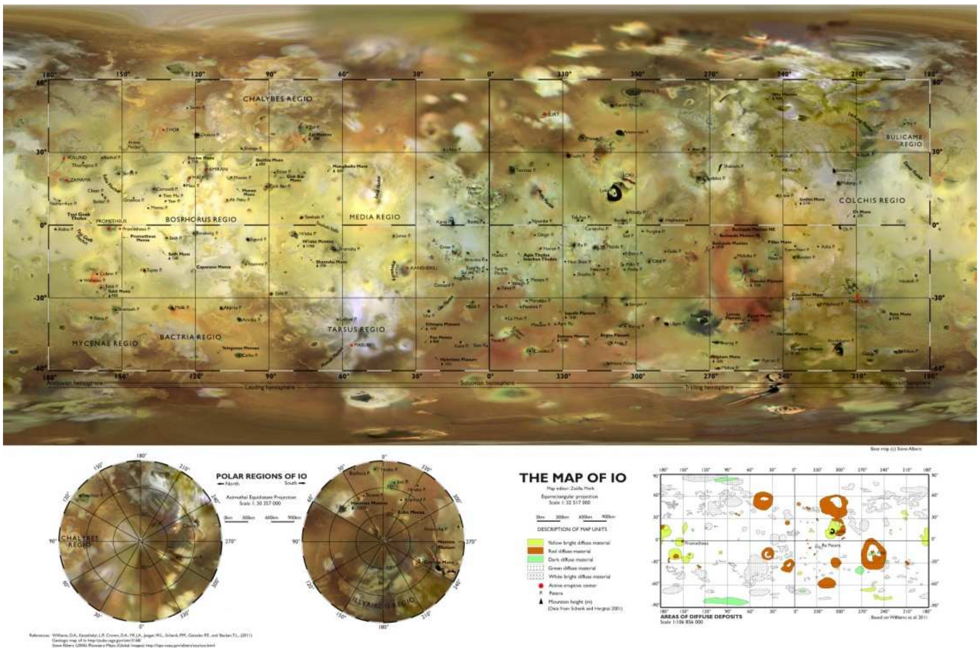

Figure 2. Preliminary photomap of Io. 2-D planar version. (Merk 2012)

3.1. Technical details behind virtual globes

The technical realisation of these virtual planetary globes include three different methods.

(1) The first one is a KML super-overlay (raster map mosaics with different levels of detail) which can be opened by any geobrowser software, such as Google Earth. Although KML format was originally designed for terrestrial use, it can contain a special attribute ("hint") to define another target planet. Currently this feature is only used by Google Earth and can be either "Moon" or "Mars". The greatest advantage of the KML technique is that the content of the virtual globe map – forming a new layer in the geobrowser – can be examined together with other geospatial data such as imagery data of the planet or any georeferenced raster or vector data. It also has a drawback, however: without a geobrowser it is unusable, which can limit its use on web pages.

(2) Another method is to drape the globe maps to a 3D globe model, defined either in VRML or X3D. These models can be embedded into web pages. The problem of

this solution is that a VRML/X3D plug-in is required at the user-end to display the globes.

(3) Luckily a new technology, the X3DOM framework, can solve the problem of VRML plug-ins. This is JavaScript library which allows X3D code to be embedded into HTML5 files, transforming X3D elements into organic parts of the Document Object Model (DOM). The library uses WebGL for visualization, which is now supported by most web browsers. X3DOM also has a fallback mechanism which uses a Flash viewer where WebGL is not supported. Although this solution requires slightly more computing power than the use of KML files, embedding 3D globe models to web pages with this technology has a clear advantage in comparison to the other solutions: no additional software is needed for displaying the globes and these 3D interactive, rotatable-zoomable objects can be composed into web pages just like static images.

Detailed description of these solutions can be found in Gede (2012).

4. Cartographic representation of unfamiliar landscapes

4.1. From hand-made maps to automated products

Until the mid-20th century, planetary maps were hand-drawn. The first lunar maps, made by Langern (in 1645), Hevelius (in 1647) and Grimaldi (in 1651) showed different planets because of different visualization and nomenclature concepts. Hevelius' map visualizations was more Earth-like and contemporary, showing not craters but circular mountain ranges, mirroring the geography of the Mediterranean in both visual and verbal representation, whereas Riccioli's map, supported by the visual representation of Grimaldi (Vertesi, 2007), was more alien, showing features with no attempt to find their terrestrial counterparts, with abstract names and names of ancient scientists and philosophers. Similar differences could be seen for the first representations of Mars. These are aimed to be objective and scientific representations, but they are in fact artistic representations. Some of the workers, like the German Beer and Mädler, or the British Green tried to be as objective as possible, showing the same blurred spots as they were seen through the telescopes. The public, however, more accepted the maps drawn by Schiaparelli, who first made sketches based directly on observations, and then "refined" these drawings to make the final map, by "augmenting" the blurred boundaries, making them sharp lines. Green criticized only the artistic style of the drawings, not the content itself (Lane 2006). Green in a letter sent to Schiaparelly wrote that "We evidently intend the same thing though we have a different way of expressing it." (Green 1878 cited by Lane 2006:23)

This is clearly an interpretation of the actual surface features, but the for general public, these maps with sharp lines seemed to be superior over the blurred maps of Green and other authors. The use of mythological names in his nomenclature made it even more terrestrial and seemingly deeply rooted in classical ancient Roman and Greek culture, then the names appearing on the other maps, that mainly showed names of contemporary astronomers, or simply letters. Eventually, this "sharpening filter" of Schiaparelly turned out to be more than just a question of difference in artistic styles: it led to the "discovery" of the "canal system" of Mars that was again accepted by the public because (Lane 2006) of the its seemingly objective and very clear representation and the logical and very terrestrial, antropomorphic theories (a "canal-paradigm") behind it, and also because the whole "big picture" was well known from terrestrial experiences of the American West (Morton 2002, Markley 2005). The canal controversy sparked an interest that eventually led to the in situ exploration of Mars (Markley 2005).

These examples show that the public will accept and understand maps if they show a clear image and can invoke terrestrial analogues in the map readers' mental map. The maps produced from automated data are not such; reality is too complex. To make it simple, interpretation, a human hand is needed.

4.2. Future goals: globes made by graphic artists – from automated products to hand-made maps

Virtual globes of planetary surfaces made of actual automatically derived topographical data are still too complex. In order to make it interpretable at K-12 school level, it requires simplification and generalization. Its nomenclature should be in the mother tongue of the pupils, and its visual appearance should only show the very basic features on the planet or moon, as very small scale global maps on Earth show continents and oceans, deserts and forests, mountain chains and main cities in a very simple way. It is not possible to create such visualizations by using any automated process. In the next phase of this project, professional graphic artists, cartographers and planetary scientists together will create simple, visually attractive and still scientifically accurate maps to create the planetary equivalents of well known very small scale global cartographic visualization of the Earth. (An example of this style can be seen in *Figure 3*.) This globe is planned to use simple symbols, non-scalable labels and show only the major types of landforms and other surface features on planetary bodies, to give a general overview of the basic surface properties of a planetary body. This map will be transformed to a virtual globe and be published in several localized versions, in several language variants and will extensively use the possibility of having „points of interest” with auxillary images and text, that can provide additional information on the features displayed on the globe.

Figure 3. A cartoon-like representation of Mars, showing the major physiographic features. Title frame from an outreach video produced by Jet Propulsion Laboratory in 2012. Major features are clearly recognizable. http://www.nasa.gov/multimedia/videogallery/index.html?media_id=154944441

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