
The Realization of ICA Commission Projects on Planetary Cartography

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Abstract

The International Cartographic Association (ICA) Commission on Planetary Cartography was officially established on the basis of the ICA Planetary Cartography Working Group at the ICA Congress in Ottawa in August 1999. Its goal is to develop materials and information intended to aid in the global dissemination of planetary cartographic information. The overall theme of this effort is the harmonization of international planetary cartographic activities. The commission's activities can help especially in those countries not actively involved in ongoing spacecraft missions, bringing together scientists from diverse backgrounds (planetary science, earth science, cartography) who have not interacted previously, along with map and atlas publishers. The Planetary Cartography Database, the Multilingual Planetary Maps, and the Multilingual Glossary can serve as a reliable resource for cartographers who wish to produce and study planetary maps.

Keywords: planetary maps, terminology, database, multilingual, glossary, extraterrestrial geography

Résumé

La Commission sur la cartographie des planètes de l'Association Cartographique Internationale (ACI) a été officiellement créée à partir du Groupe de travail sur la cartographie des planètes, dans le cadre du congrès de cette association à Ottawa en août 1999. Son objectif est d'élaborer des documents et de recueillir des renseignements visant à contribuer à la diffusion globale de l'information liée à la cartographie des planètes. Le thème général de cet effort est l'harmonisation des activités en matière de cartographie des planètes. Les activités de la commission aident tout particulièrement les pays qui ne participent pas activement aux missions spatiales. Elles permettent de réunir des scientifiques aux antécédents divers (science planétaire, science de la terre, cartographie) n'ayant jamais travaillé ensemble, de même que des éditeurs de cartes et d'atlas. La base de données sur la cartographie des planètes, les cartes multilingues et les glossaires multilingues sont des ressources fiables pour les cartographes qui veulent produire et étudier les cartes des planètes.

Mots clés: cartes des planètes, terminologie, base de données, multilingue, glossaires, géographie extraterrestre

Introduction

The International Cartographic Association (ICA) Commission on Planetary Cartography was officially established on the basis of the ICA Planetary Cartography Working Group (1995–1999) at the ICA Congress in Ottawa in August 1999. The Working Group on Planetary Cartography was initially established during the 1995 ICA Congress in Barcelona, initiated by Kira Shingareva (Russia), Manfred Buchroithner (Germany) and Jim Zimbelman (USA). Kira Shingareva, chair of the group, conducted investigations of the international market in the field of cartographic products on planetary subjects. This initial survey showed that planetary cartographic materials were, and still are, almost completely absent from the overwhelming majority of nations, particularly those countries not directly involved with active spacecraft missions. Since then, commission members have begun to develop materials and information intended to aid in the global dissemination of planetary cartographic information. The overall theme of this effort is the harmonization of international planetary cartographic activities. This, however, does not imply the “homogenization” of planetary maps (making everything look the same). Instead, the working group and subsequently the commission wanted to foster the free interchange of ideas and information among all national efforts that incorporate some aspect of planetary cartography, along with improving the accessibility of planetary information to all nations (Shingareva, Krasnopevtseva, and Zimbelman 1999). The commission’s activities can be followed at its Web site: <http://www.nasm.si.edu/ceps/ica>.

Currently the following activities are ongoing within the commission:

1. Development of a Multilingual Planetary Map Series
2. Compilation of the first Multilingual Glossary of Planetary Cartography
3. Elaboration of a GIS for Extraterrestrial Territories, with a specialized Planetary Cartography Database

The following report provides additional details about each of these efforts.

The Multilingual Planetary Map Series Project

Based on already completed missions and those endorsed by various national space programs, the number of missions to celestial bodies will steadily increase during the coming years, with both orbiters and landers sent to various celestial objects. A set of maps should increase the interest of the global public in the “geography” of extraterrestrial territories. In particular, interest in Mars increased considerably after the successful Mars

Pathfinder mission in 1997, continued to grow with the currently active Mars orbiters and twin Mars Exploration Rovers, and should only continue to grow with proposed missions to search for organic compounds in the Martian rocks and soil, retrieve Martian materials for study on the Earth, and, eventually, carry out piloted missions to Mars. Thus the compilation and publication of a multilingual map of Mars was the obvious first choice in what eventually became a proposed series of multilingual planetary maps. Manfred Buchroithner coordinated the printing of marginal information on the Mars map in five different languages: English, German, French, Spanish, and Russian.

The preliminary version of this map of Mars, at a scale of 1:35,000,000, was initiated by the Moscow State University for Geodesy and Cartography (MIIGAiK) in cooperation with the Institute for Cartography at the Dresden University of Technology (TUD) (Buchroithner 1999a). MIIGAiK produced the compilation of the base map, with a shaded relief representation of the major topographic features, along with selected scientific information. TUD translated all the marginal information into the other four languages, compiled the map with the scientific information in all five languages, and printed the composite map and text. This map was first publicly displayed during the National Map Exhibition at the 1997 ICA Conference in Stockholm, which served as a test of the international interest in such multilingual maps.

The overwhelmingly positive response to the preliminary Mars map encouraged us to proceed with the production of a higher-quality map. The preprint version was 77 × 57.5 cm; each of the two displayed hemispheres was 27.5 cm in diameter. After considerable discussion, the final version of the Multilingual Map of Mars was prepared. In addition to the map itself, additional information was printed around the two Mars hemispheres in all five languages. Since the main goal of the Mars map was a highly accurate depiction of its overall relief and major physical attributes, we strove for a high-quality representation. The base map finally chosen was a manually produced hill-shaded representation in two hemispheres, drawn in pencil on transparency film at a scale of 1:25,000,000. The final map was based on an earlier version by Hellmuth Wolf (1984), supplemented with images obtained by various Mars missions (e.g., Mariner, Mars, Viking). The shaded relief simulates illumination from the west, with an incidence angle of $40^\circ \pm 3^\circ$. So far, the pencil-drawn film version appears to be the most adequate depiction of the diverse geomorphologic features present on the entire planet: volcanic mountains, table mountains (mesas), grabens, valleys, and so on are all clearly perceived. The hill shading was produced by G.S. Grigoryeva, L.S. Oreshina, and L. Baeva of the Planetary Cartography Laboratory of

MIIGAiK. The overall quality, richness in detail, and size of the original shaded version resulted in a final map scale of 1:25,000,000 (38.4 cm diameter/hemisphere).

It soon became evident to commission members that it would be advisable to print the marginal information in text blocks on the back of the map sheet, instead of on the front, where the map itself is printed. For the production process, conventional reprographic methods were applied, using a repro screen of 54 points/cm for the shaded-relief original. Every effort was made to optimize the reproduction of the relief representation; in particular, a balance was struck between the bright tones of the *vastitates* (plains) and the dark patches of the shaded east-facing slopes of volcanoes and grabens. The coordinate grid of the map, whose geometry is based on the Transversal Equivalent Azimuth Projection of Lambert, shows every twentieth parallel and meridian (Figure 1).

This map became the first phase of a larger project: the Multilingual Planetary Map Series. Using the same methods employed for the Mars map (preliminary version, discussion, final version), comparable multilingual maps of Venus (Buchroithner et al. 2002a), Earth's Moon (Buchroithner et al. 2002b), and Mercury (Buchroithner et al. 2005) were prepared during the next five years. Although the maps were developed as a series, each has individual design characteristics. For instance, half of the map of Mercury is a shaded relief map, while

the other half is an albedo map, since as of today only 40% of Mercury has been adequately photographed for a detailed representation. The hemispheres of the celestial bodies each have the same printed sizes in this map series, and hence the scale varies for each map.

By 2005, the following maps have been published (preliminary version / final version):

- Mars (Stockholm 1997 / Ottawa 1999) (Buchroithner et al. 1999)
- Venus (Beijing 2001 / St. Petersburg 2002) (Shingareva and Krasnopevtseva 2001)
- Earth's Moon (St. Petersburg 2002 / Durban 2003) (Shingareva, Krasnopevtseva, and Buchroithner 2002)
- Mercury (Durban 2003 / Moscow and Vladivostok 2004) (Shingareva and others 2003)

A map of the Martian satellites Phobos and Deimos is currently in preparation, and its publication will conclude the first part of the map series. Eventually, this series will continue with the compilation of multilingual maps of the Galilean moons of Jupiter, along with other large satellites in the outer solar system and asteroids that have been adequately imaged.

OTHER EDITIONS OF THE MULTILINGUAL PLANETARY MAP SERIES

The next phase of the Multilingual Map Series involves compiling planetary maps using the same shaded-relief

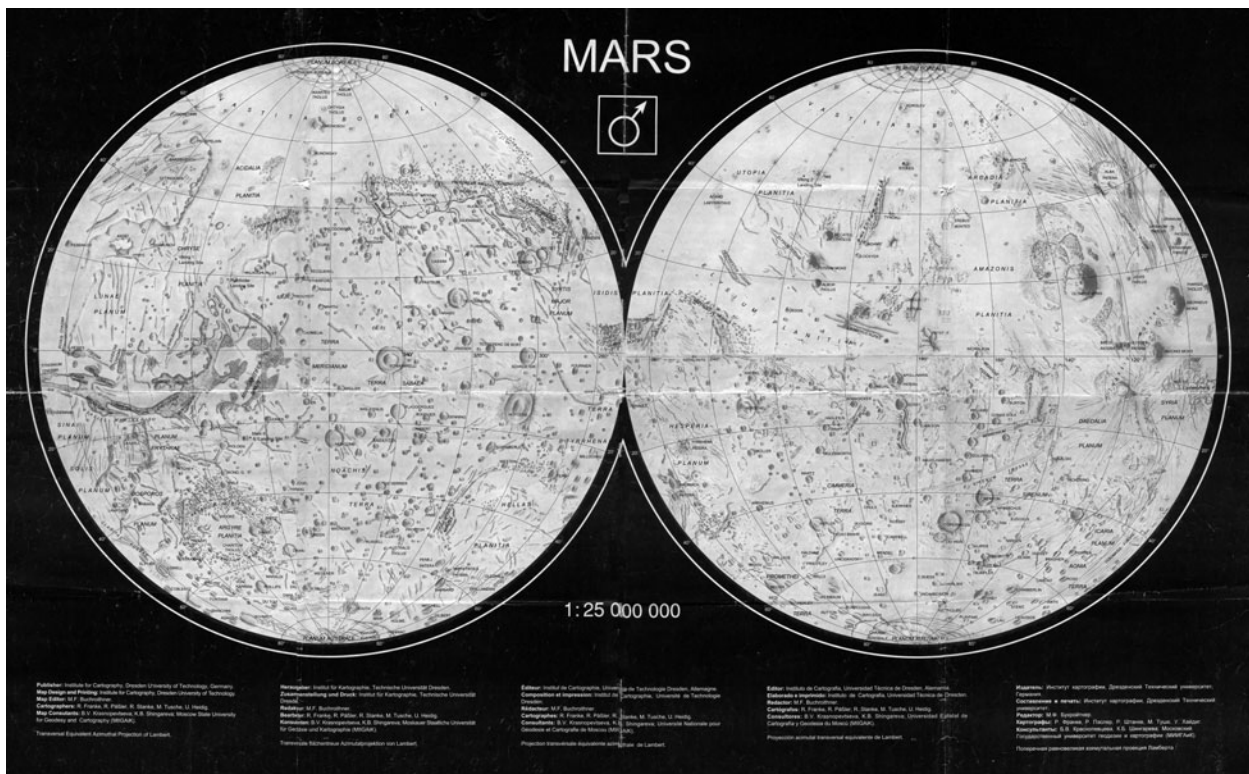


Figure 1. Map of Mars, 1999, published by the Institute for Cartography, Dresden University of Technology, Germany (Buchroithner 1999a, 1999b), scanned from a colour original.

base maps described above, but for an additional group of languages and with some modifications to the map content and its representation. This cooperative effort is coordinated by the Cosmic Materials Space Research Group of the Eötvös Loránd University in Budapest (ELTE), in consultation with both Russian and German colleagues. The new maps are the result of cooperation between MIIGAiK, ELTE, the Copernicus Observatory and Planetarium in Brno, the Zagreb Astronomical Observatory, the Jagellonian University Observatory, the Tectonics and Geological Cartography Section of the Faculty of Geology at Warsaw University, and the University of Architecture, Civil Engineering, and Geodesy in Sofia.

The new editions contain additional multilingual information concerning planetary science results and specific characteristics of the relief of the planetary body, located in the lower margins of the front of each map; the reverse side features geography, geology, stratigraphy, history of discovery, and a full index of names. The text appears in Czech, Bulgarian, Hungarian, Croatian, Polish, and English. In some cases, this represents the first time that a particular term (along with its definition) has been translated into one of these Central European languages. After the first four maps were compiled, it was concluded that such multilingual maps can effectively draw the attention of earth scientists to the specific features – and even the mere existence – of other planetary bodies simply

by discussing the translation of the terminology applied to these bodies. Apart from circulating the maps in classrooms, the translation effort may be the most important scientific result of this particular edition.

The first map of the Central European version (Mars) was published in Budapest in 2001 (Figure 2). The maps of Mars and the Moon won prizes in the Hungarian national Lázár Deák Map Contest in the category of “Scientific Maps.” Through 2004, four sheets had been published: Mars (2001), Venus (2003), the Moon (2003), and Mercury (2004) (Hargitai and others 2001–2004) (Figures 2–5). The map of the Moon also appeared in the *World Atlas* of the Topográf Publishing Company in Hungary, but with Hungarian nomenclature. (On the original maps, the names of lunar *maria* appear in five languages, while on the Mercury map, local equivalents of Renaissance Italian and ancient Greek personal names are shown. For all other features, only the Latin name is shown.) We believe that detailed planetary maps should be included in both world and school atlases, since they emphasize so effectively the uniqueness of our own planet while showing the otherwise unknown richness of other celestial bodies, which can most easily be presented in the form of well-prepared maps.

A new, improved edition of the Venus Map was created in Polish and Hungarian for use during the Venus transit event of 2004. On this map, the visual appearance was modified: the original pencil drawing was mixed with

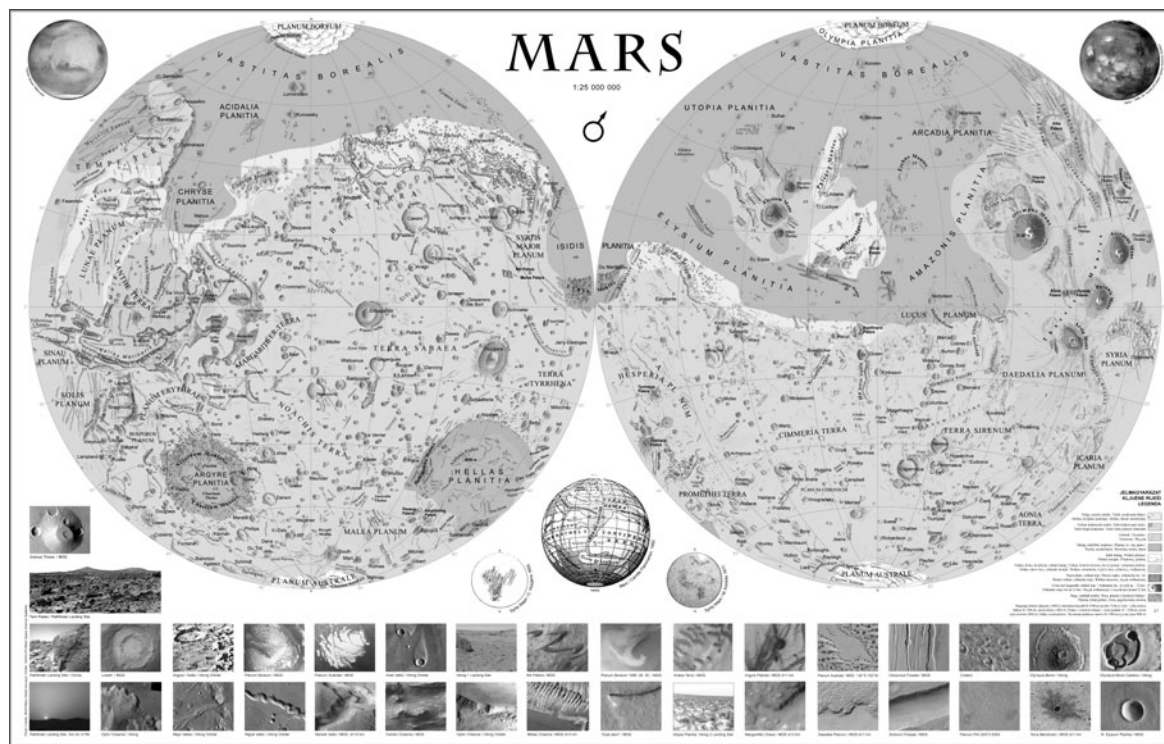


Figure 2. Multilingual planetary wall map published by the Cosmic Materials Space Research Group in Budapest, Hungary: Mars (2001). The original is in colour. (Hargitai and others, 2001–2004)

actual radar image patches and vector symbols. The new edition uses symbols for features that would otherwise be too small for representation at the given scale. To improve the overall “3D” appearance, a limb-darkening shading method was used. For impact craters, radar images were used instead of the drawing, representing their actual ejecta characteristics more realistically. Lava channels are shown by yellow lines that follow the meanderings of the channels. The same method was also used for representing *fossae*. Some lava flows that are visible in the radar images are also shown. The elevated *terrae* got a darker brownish hue, while lower *planitiae* (plains) are shown in a light orange, resulting in a “warm” or “hot” appearance. The locations of some of the smaller “geologic hot spots” (e.g., “ticks,” *farra*) are also shown. Several new names were added to the nomenclature appearing on the map and different type-faces were used for the different features, taking terrestrial physical geographic maps as examples. Wherever possible, the feature names appear parallel to the latitude grid.

On the new map the legend is given more space; it contains not only basic (morphologic) features, defined with Latin terms by the International Astronomical Union (IAU), but also other features or landscape types described and discussed only in planetary science publications. In the legend, not only “official” IAU

definitions are included but also the morphologic description and its associated geologic interpretation. The maps of Mars (2003) and the Moon (2005) were reprinted in Croatia by the Zagreb Observatory, with some minor modifications (e.g., the addition of names of ex-Yugoslavian origin, colour changes).

The maps of the Central European Edition are used by high school and university students as well as by amateur/hobby astronomers and are distributed in the East-Central European countries to high school libraries, university bookstores, amateur astronomer observatories, and planetariums. They are also available via the Internet for free PDF download at <http://planetologia.elte.hu>. We plan to extend the series with new South African and Chinese editions, and we are also looking for other language groups who could localize and publish other regional editions.

It is important that these multilingual maps reach as many readers as possible, so there are plans to publish the series in a “compact” format (i.e., a planetary atlas) primarily designed for use in high schools. The first such planetary school atlas has already been published in Moscow. (Shingareva and Krasnopetseva 2005) Both the “first” pan-European and the “second” Central European map series were displayed in A Coruna (Spain) at the 2005 ICA Conference.

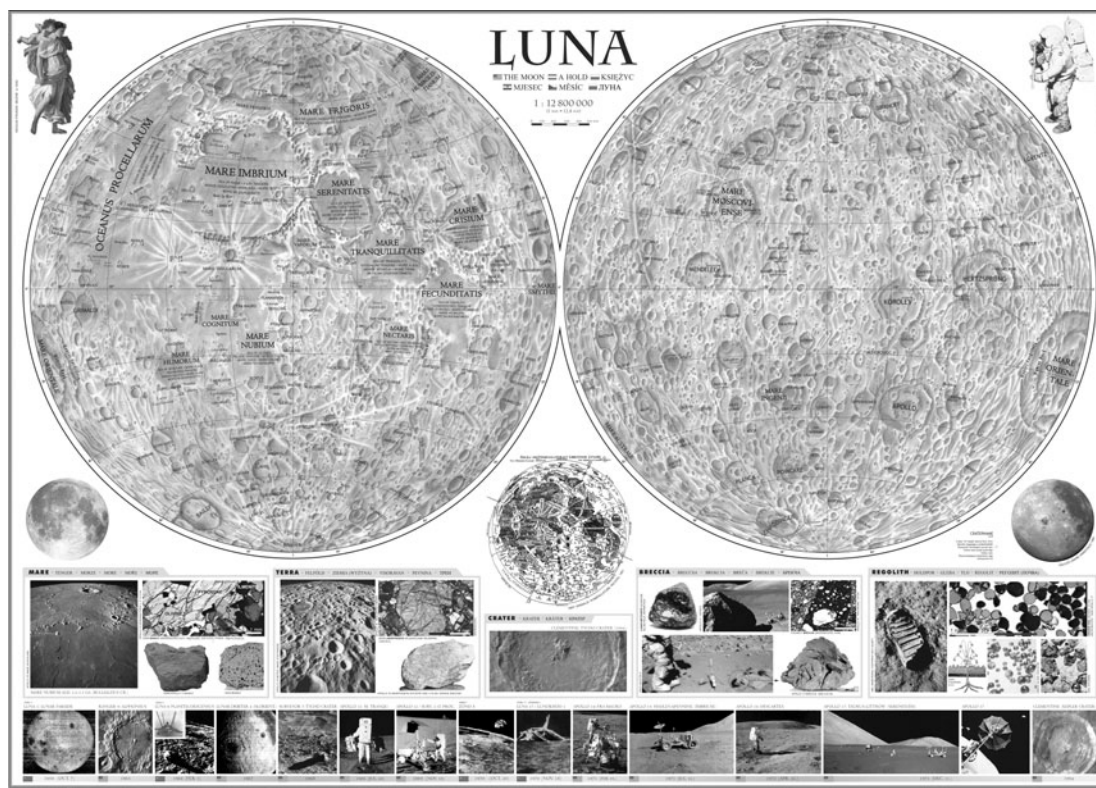


Figure 3. Multilingual planetary wall maps published by the Cosmic Materials Space Research Group in Budapest, Hungary: The Moon (2003). The original is in colour. (Hargitai and others, 2001–2004)

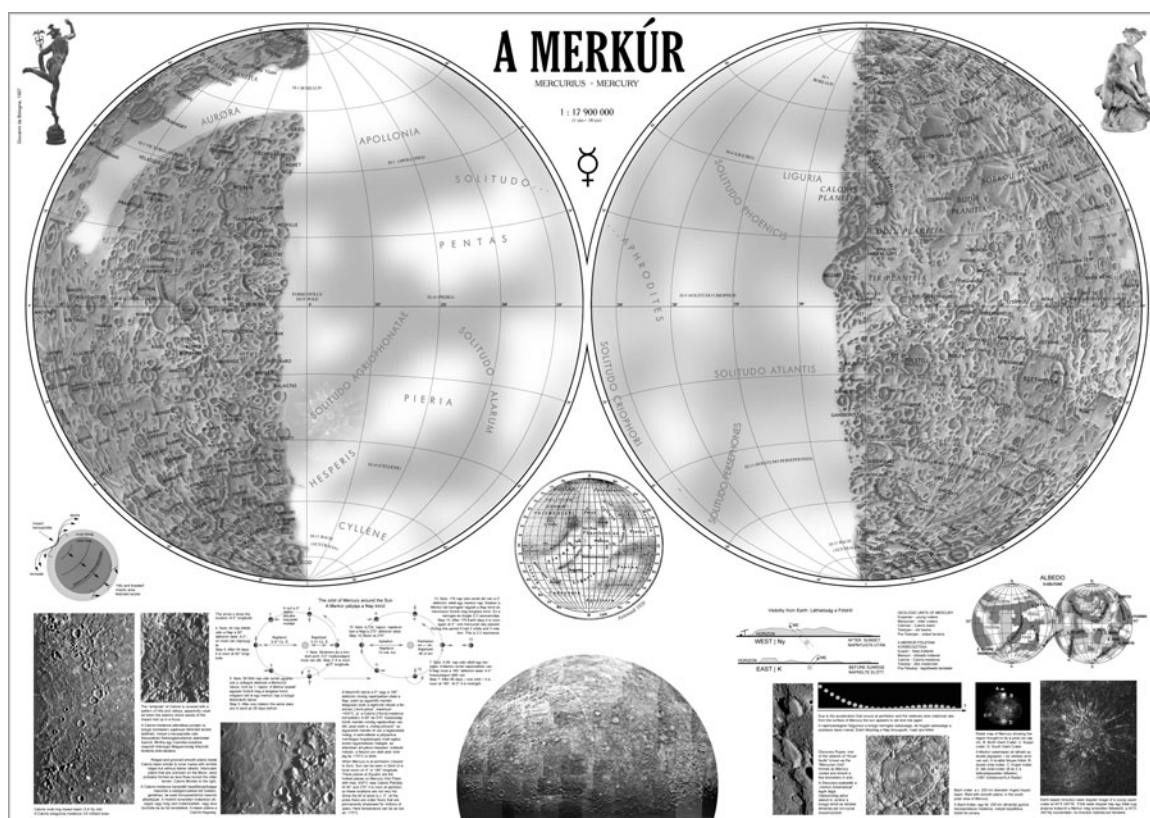


Figure 4. Multilingual planetary wall map published by the Cosmic Materials Space Research Group in Budapest, Hungary: Mercury (2004). The original is in colour. (Hargitai and others, 2001–2004)

The Multilingual Glossary on Planetary Cartography

The ICA Commission on Planetary Cartography has undertaken the compilation of a Multilingual Glossary on Planetary Cartography (Shingareva and Zimbelman, 2001). It was Shingareva's idea to compile a glossary of terms frequently used in planetary maps, as well as a list of mapping terms from various countries in different languages, in a way that can be used to identify features on planetary maps. In some cases, English translations of Russian terms or names appearing in international publications are different from the terms used by American authors (e.g., in nomenclature: some catenae on the far side of the Moon; in terminology: the word for "spacecraft" translated as "space station" or "orbital station"). In other cases, the same surface feature type has different names in the classification systems used by various authors (e.g., the various ejecta types for craters on Mars, or the coronae on Venus) or similar phenomena are named differently on different planets (e.g., "terrain softening" and "relaxation"). Some IAU generic terms refer to features of very diverse origin (mons/montes: from volcanic cones to crater ejecta; catenae: from collapse pits to a valley of eroded craters).

After new discoveries, "old" terms are often not used in the scientific literature but (at least for the Moon and Mars) are still used by amateur astronomers (e.g., albedo features of Mars, mountain names on the Moon) or are used with a different (or more specific) meaning (e.g., "corona" and "arachnoid"). Numerous informal place names do not appear on "official" maps but are widely used in the popular literature (e.g., "Inca City," "Cobra Head," "Frozen Sea"). Another problem is the use of terms by the popular media, some of which are confusing even among scientists (e.g., the confusion between the definitions of central pit and peak ring craters of Mars; the threshold size of "craters" and "basins"; the names of vehicles making fly-bys of or orbiting the Earth, the Moon, the planets, the Sun, or even the Lagrangian points; the terms "astronaut," "cosmonaut," "spationaut," etc.; the differentiation of the words "meteor," "meteorite," and "asteroid") (Almár 2005).

The need for correct definitions and a standardized orthography for astronautical (Dezso and Kálmán 1979) and planetary science (Hargitai and Kereszturi 2002) terminology is not new. This effort requires a "correlation" database of terminology (see Barlow and others 2000 as an example for Martian craters), as well as well-prepared definitions that can be used by scientists,

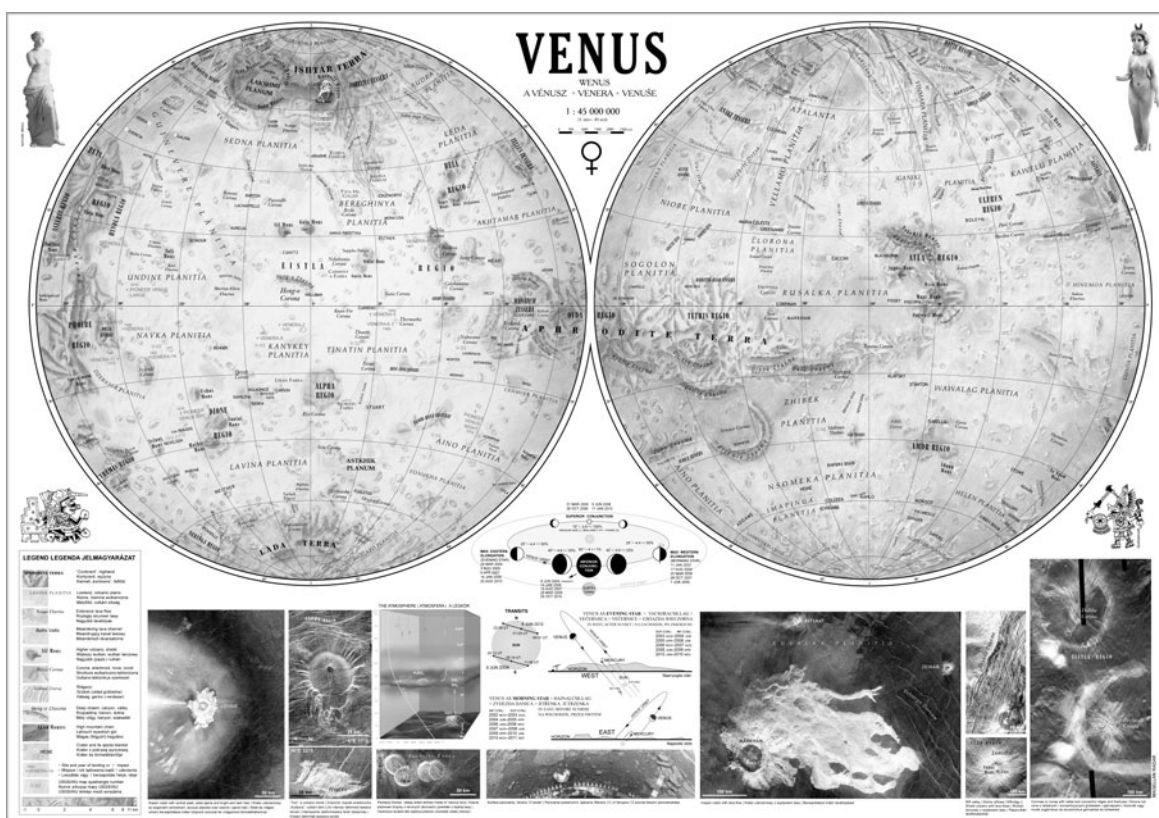


Figure 5. Multilingual planetary wall map published by the Cosmic Materials Space Research Group in Budapest, Hungary: Venus, second edition (2004). The original is in colour. (Hargitai and others, 2001–2004)

students, the media, and cartographers. For the translation – and sometimes the creation – of the terms to be included in the glossary, it is necessary that the translator be aware of the local geologic terminology, understand the nature of the particular feature, and be able to give names that are linguistically correct and in harmony with the terms used in practice by geologists and planetary scientists.

The current effort by the ICA Commission is the first attempt to collect these terms and give them corresponding definitions. Today the preliminary version includes around 150 terms, but this number is continually growing. Thus far, the glossary content exists only in English and Russian (ICA 2001). The first version of the glossary includes

1. General terms
2. Special terms in planetary (extraterrestrial) cartography
3. Terms of cartographic products
4. Original (IAU) terms and definitions of the relief features of planetary bodies with solid surfaces in Latin and English (planetary nomenclature)
5. Morphologic and geologic terms of the relief features of bodies of the solar system
6. Terms related to thematic cartography
7. References

The first version of the glossary was prepared in cooperation with colleagues from Russia, the United States, and Germany. Some of the international organizations with which commission members are interacting (with regard to additions and corrections) are the Planetary Cartography and Geologic Mapping Working Group, the National Aeronautics and Space Administration (NASA), the International Astronomical Union (IAU) Nomenclature Committee (by which all names on planetary maps must be approved), the Laboratory of Comparative Planetology (RAN) in Russia, the Moscow State University for Geodesy and Cartography, and the University of Armed Forces in Munich, Germany. The preliminary version of the glossary was introduced and discussed at the 2001 ICA Conference in Beijing and has been made available on the Internet (ICA 2001).

The next step in this process is the compilation and editing of a true multilingual glossary. The same group of languages described above for the map series has been selected for the first version of this glossary. In the future, it will be possible to expand the glossary to include additional groups of languages, using the experience gained in preparing the first glossary. The 16-language *IAA Multilingual Space Dictionary* (published in Budapest in 2002) (Almár 2002, 2005) or the six-language

Astronomical Dictionary (Kleczeck, 1961) can be used as examples of the expansion process. The basic concept is to list the English terms with their definitions in alphabetical order with successive numbers, then arrange their foreign equivalents in corresponding columns. For example, number 18 in the English list reads, “*Extraterrestrial territories* are territories located off the Earth and have a solid surface or separate segments of a rigid surface.” The terms in the other languages are also given in alphabetical order, keyed to the number from the English list. Following on the above example, we find “*Ausserirdische Territorien*, no. 18.” in the German list. The current version of the glossary (350 terms) was presented at the 2005 ICA conference in A Coruna, Spain.

The group at Eötvös Loránd University is currently working on a new series, Surface Features of the Solar System, in which all name variants (and their abbreviations) for each feature type are given, together with a definition (or description and interpretation), images of typical examples, and the names of the various parts (or elements) of the feature, in both English and Hungarian. The volumes of this series will discuss impact, volcanic, erosional (aeolian, fluvial), and tectonic features; the first of these (impact features) is already in print. This is the first attempt to collect and correlate all terms related to impact processes and features that are, or have been, used by various authors.

Planetary Cartography Database

We analysed several existing databases of planetary data (Shingareva 2000): the Planetary Data System (PDS) of NASA, the Center of Mars Exploration (CMEX), the Malin Space Science System (MSSS), and others. Our analysis showed that these databases consist of a block of programs for educational and outreach purposes, oriented toward individual missions, and primarily for use in scientific research. These databases all use hypertext-based Web visualizations, but they are not oriented toward doing detailed work using various thematic *maps* of planets and their moons in a GIS environment. The PDS was created in the United States in order to provide Web-based access for the scientific and general public to the new information returned to the Earth by the many robotic space missions throughout the Solar System. In recent years, this system has been upgraded several times with the addition of various new parts. The database has become very complex, with users awaiting the next modification. The PDS database contains hundreds of thousands of images of celestial bodies at various scales. Other on-line research databases that include images, along with detailed morphometric, topographic (height), or geologic data, also exist for selected feature types of various planetary bodies: the crater database(s) of Mars,

Callisto, Ganymede, Venus, and Earth or the mountain database of Io are a few examples (EID 2003; Herrick n.d.; Schenk 1996a, 1996b; Hargitai and Schenk 2003). In these databases, specific features can be searched for by using their coordinates, names, or another morphological descriptor. Other on- or off-line databases do not include images for each individual feature (Rodionova 2000; Barlow and Bradley 1990), which is essential raw material for cartographers.

We concluded that the existing planetary databases are not yet sufficiently universal. That is why it is useful for the scientific community to develop a solar system bodies databases *with map-oriented data access*. The main content of this new database will be thematic maps characterizing such aspects as morphology, gravity anomalies, hypsometry, colorimetric and polarimetric properties, and climate parameters for entire celestial bodies, as well as more detailed maps of selected areas of special interest. The database content must include a large number of geographic and thematic maps of diverse bodies of the solar system, but it also must take into account the specific characters of unique celestial bodies and the current level of their investigation. In addition, the mathematical bases for the maps, such as data describing relief features with their characteristics and orbital or physical data on the properties of the bodies, would also be included.

The database structure will organize these diverse data into various levels for different groups of users (Leonenko and Shingareva 2003). The planned levels will depend on the map scale needed by each user as well as on the accuracy level and the map density of the cartographic information to be displayed. Users can define how much detail they require for their individual purposes (e.g., levels for the scientist, non-specialist, student, and child). The cartographic information must be given not only for the whole celestial body but also for areas of special interest. The electronic version of the *Atlas of Terrestrial Planets and Their Moons* (Bugayevsky, Shingareva, and Krasnopevtseva 1992) will be used for base maps during the first stage of database compilation.

GeoDraw/Geograph, which is also capable of creating a GIS suite of data products, has been chosen as topological editor for the digital maps in the database. The structure of the spatial data of a digital map (including the relations of connectivity, contiguity, neighbourhood, and enclosure of objects) allows the relations between spatial objects and their attributive data to be changed. GeoDraw allows transformation of maps into other GIS formats (both topological, such as ArcInfo, and non-topological, such as MapInfo). The projection can be chosen from more than 40 standard types, and the software can integrate digital “map sheets,” which can work with several maps to form a multilayered structure at various scales (from 1:500 to 1:50,000,000).

The main goal of the new database system is to bring map-oriented information to a wide array of potential users. Two main user groups can be defined: those who use the database for educational purposes (students, teachers, amateur astronomers, etc.) and those who use it for scientific (research) purposes (e.g., to select candidate sites for future exploration). The system will be built using the principles of geo-information systems, that is, using a large number of thematic layers. For the “general interest” user group, thematic maps with different layers can be used. This group needs carefully visualized data, readily available in well-prepared “map kits.” On the other hand, researchers will need both raw and processed data with high precision and will need to be able to work on multiple layers using various scales all at the same time. This database will include a scientific information section with results from various planetary missions, including data from and about each mission; data from terrestrial observations (e.g., telescopic photographs or drawings); and the main results from scientific investigation (e.g., theories, models, and hypotheses developed for interpreting the data). The database would also include descriptions and bibliographical data for the published maps of any particular planetary body. As a cartographic base, two maps at scales of 1:50,000,000 and 1:5,000,000 will be used. In order to provide better opportunities for searching and selecting areas of interest to transfer to the next map, the base map is divided into blocks corresponding to individual map sheets at a scale of 1:5,000,000. It is possible that a shaded relief representation of topography will be used as a base map. The main idea is an application of various layers with thematic content or – if the user needs it – with only a coordinate grid, names of relief features, orbit tracking, and so on. The proposed map-oriented database will allow diverse users to perform numerous tasks: for example, to display the map of a celestial body along with images of its surface, taken at various resolutions and obtained from different missions; or to select areas for future exploration. Such a universal database could serve as a basic tool for use in astrogeology, where most information is available in visual formats, such as images and maps.

Conclusion

The projects presented in this paper can only be realized through truly international and multidisciplinary cooperation. While in the United States, Russia, Germany, and so on there are institutes specialized in planetary cartography, this is not the case in a large number of countries, even in Europe. The ICA Planetary Cartography Commission's activities can help – especially in those countries not actively involved in ongoing space missions – to bring together scientists from diverse fields (planetary science, earth sciences, cartography) who have

previously not interacted, along with map and atlas publishers. The Planetary Cartography Database, the Multilingual Planetary Maps, and the Multilingual Glossary can serve as reliable resources for cartographers who wish to produce and study planetary maps. These products can also be used for educational purposes and for basic research. As an initiation of “localized” planetary map production, we have already produced a series of Multilingual Planetary Maps of the Terrestrial Planets and Their Moons (a series of six individual map sheets). Currently the series is published in three countries (Germany, Hungary, and Croatia), with information listed in 10 languages. In many cases, this is the first such product of planetary information in a particular language or country. In this way, planetary maps, together with planetary science terminology, can become an integral part of scientific activities in the countries served by the multilingual products and can be brought to the general public using correct (and perhaps standardized) terms in the native languages of their users. Our long-term goal is for the database, the glossary, and the planetary maps to raise currently declining public interest in the geography of extraterrestrial territories.

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