PLANETARY CARTOGRAPHY: GOALS, TASKS AND OUTLOOKS FOR ITS DEVELOPMENT

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Abstract

The role of cartographic methods in planetary research is emphasized. The evolution of the mathematical basis of maps is presented for the bodies of significantly non-spherical shape. The outlook for the creation of special atlases of inquiry and encyclopedic character is considered for the planetary research.

1 General information

Usage of cartographic methods in planetary research makes it possible firstly to visually represent the surface of this or that body on a map or a globe. The choice of a cartographic projection specifies the character and the value of distortions resulting from this reproduction. With taking into consideration the distortions it is possible to get the knowledge about the mutual location in space of certain formations and their metrics since the measurability is the most important property of cartographic images.

2 Goals and tasks of the planetary cartography

Presently cartographic products mapping celestial bodies are necessary for achieving certain goals of both the scientific and applied character. First of all they are related to the following tasks:

- visual representation of space research results;
- navigation support of missions towards celestial bodies;
- development of extraterrestrial areas; and
- dissemination of the knowledge on celestial bodies.

The circle of tasks to be solved by the planetary cartography significantly increases. First of all here there should be considered the tasks connected with the increase of the number of trends, together with the specific weight of thematic mapping. Along with studying the features of the surface morphology the role of maps of the surface physical properties and of geophysical and geomorphologic maps, together with the role of the geochemical property maps and the maps of special application significantly increase. Study of spatial distribution of this or that phenomenon on the surface of a celestial body helps to specify the correlation between groups of phenomena related to various categories. The analysis reveals the correlation between the surface structure and the internal structure of a celestial body. The basic maps used for this make it possible to locate the special information relative to the real relief. Simultaneously in the recent years surface simulation trend has been developed on the basis of a statistical analysis of the independent relief feature distribution. The application destination of the maps of celestial bodies is mainly reduced to the support of space missions. In the field of the mission navigation support the following applications can be marked out: direct support of missions towards celestial bodies; support of landings on these bodies and support of the programs of conducting experiments both on the surface and in the near-planet space. In connection with the preparation of the lunar base the support of applied works on the lunar surface including construction engineering, transportation network development and industrial construction engineering becomes of current interest. In addition the creation of various cartographic products for the educational, inquiry and demonstration purposes is one of the main tasks of mapping celestial bodies.

3 Specificity of map product development

3.1 Map mathematical basis

When mapping celestial bodies the development of mathematical basis of cartographic products plays an important role. As a rule the center of the reference ellipsoid is assumed to coincide with the center of mass of a planet or a moon and the polar axis - with the axis of rotation. During the pre-cosmic and transitional periods of mapping celestial bodies the sphere was practically the only simulation surface. With the appearance of new data which allow to revise the shape and dimensions of the Solar system bodies, the ellipsoid of rotation with small polar oblateness (e.g. for Mars) was put into usage as the reference surface. Then for the first time the triaxial ellipsoid was tried for Phobos. As to the Moon a sphere should be considered as the first approximation of the reference surface. Study of the character of the equipotential surfaces near the Moon surface (the shape of the lunar geoid) has put certain reasons for using the triaxial ellipsoid as the next approximation. However the choice of the reference surface will be the most significant for the bodies of a sufficiently irregular shape and namely small moons of the giant planets, asteroids and nucleus of comets. It should be noted that presently reference surfaces at most approximating the real physical surface of a celestial body are being developed.

3.2 Co-ordinate systems of the mathematical basis

Co-ordinate systems are an impotant component of the mathematical basis. At the international level the planetocentric and planetographic co-ordinate systems are specified and legalized for such celestial bodies as the terrestrial bodies and their moons and the moons of the giant planets [1]. Co-ordinate systems used in the planetary cartography are as a rule the co-ordinate catalogues for a certain number of reference points on the surface of these bodies. They are represented by clearly distinguished relief features (craters, separate tops of mountains, etc.). As distinct to the lunar catalogs based both on the data obtained from the ground observations and the data from space survey, the catalogs of Mars, Mercury, Venus, etc. are the result of the exclusively photogrammetric processing of the imagery.

3.3 Choice of projections

The choice of projections for the maps of celestial bodies is a complex task since it is necessary to take into account several factors connected with the specific features of the celestial bodies. Among those we should consider the specificity of their shape for small-scale mapping, the necessity to determine the optimal projections for the areas and regions of the top prospect for research.

4 Stages of data acquisition for mapping Solar system bodies

At the present time it is possible to mark out the next three stages of obtaining the data required for mapping the Solar system bodies:

- acquisition of imagery series and first of all in the optical band (using radars in the case of the dense atmosphere);
- data acquisition in different spectral bands; and
- accumulation of various data about the groups of celestial bodies.

The first stage creates the pre-requisites for compiling geographical maps, the second one – for thematic maps and the third one – for the development of map series intended for the data analysis from the point of the comparative planetological aspect. Specificity of contents of geographical maps results from the fact that the main component of their contents is do the relief. This specifies the tasks of the relief representation – to be able to point out the common to all the celestial bodies and at the same time to shade the specificity of certain relief features typical for this celestial body. Along with the surface

maps representing the relief by shading the outline maps are of wide usage as well. For these maps the relief is represented by a system of hatching conventional signs. These maps are called up to play three different roles. They appear as independent maps to mark out specific features of the surface relief by conventional designation, supplementing and explaining by this the surface maps produced by the shading technique. They serve the basis for thematic maps allowing to foreground the thematic contents accomplishing at the same time the location to the real relief. In addition they can serve a basis for sketch maps and various illustrations. Thematic maps are widely used for studying spatial distribution and inter-relations of various planetary characteristics. The maps of special purpose are first of all called to provide safety for landing on the surface of a celestial body (slope maps, maps of "danger", etc.). At the same time such kind of maps should spin-off the developments connected with the future mastering celestial bodies.

5 Outlooks for the development of the planetary maps

In future it seems expedient to create special atlases on planetary research of the inquiry and encyclopedic character. Systematics and complex approach should form the basis for the atlas mapping of celestial bodies. Here three main trends connected with the continuity of stages of mastering the Solar system bodies: from the reconnaissance (introductory) up to the total one:

- creation of the atlases consisting of original image series for the surface of the celestial bodies; the same series but of improved images (after computer processing); and the series of images with the printed-in map grid (1st type);
- creation (as the materials are being accumulated) the complex atlases on certain celestial bodies representing all the scope of our knowledge about these bodies (2nd type); and
- creation of complex atlases for the groups of celestial bodies (e.g. the terrestrial planets and their moons, moons of the giant planets, asteroids, etc.) which allow to analyze the presented information from the point of the comparative planetological aspect (3rd type).

In future a transfer from the local mapping of celestial bodies (reconnaissance approach) to the global one (total survey) has outlined.

References

[1] Report of the IAU Working Group on Cartographic Co-ordinates and Rotational Elements of the Planets and Satellites. 1982 M.E. Davies, V.K. Abalakin et al. Celestial Mechanics, 1983, v. 29, p. 309-321.