

## MAPPING OF THE SOLAR SYSTEM BODIES ON THE BASIS OF SPACE DATA

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### Abstract

A brief analysis of the cartographic studiness of the Solar system bodies is presented. The conclusion is made that space survey has resulted in the creation of maps and globes of the terrestrial planets and their moons and of maps of the moons of the giant planets. At the same time the survey has promoted mapping the asteroids and the nuclei of comets. There are absolutely no mapping data about the Pluto-Charon system.

### 1 General information

In the recent decades the cartography of extraterrestrial bodies have gained a strong source of data due to the space technology. Automatic and manned spacecraft (s/c) surveyed surfaces of celestial bodies on the most diverse scales (from 1:10 up to 1:100,000,000) with various coverage (from local sites up to the global coverage) and resolution and in diverse spectral bands. That has resulted in the intensive production of not only the geographic surface maps but thematic maps for various applications either.

### 2 Classification of survey

It is possible to subdivide space survey purposefully conducted for mapping surfaces of celestial bodies into two distinct stages. Ten years of 1970-79 were dedicated to the intensive survey of the terrestrial planets and their moons. The next 10 years (1980-90) possess widening of surveying range and survey of the giant planets and their moons, of comets and asteroids. These bodies are considered the objects for mapping. At the same time survey of the terrestrial planets and their moons was performed in parallel but not so intensively. The space survey was conducted both when approaching the surface or directly from the surface of the celestial bodies and from the orbits of their artificial satellites. As for the area coverage the survey is classified for local, regional and global ones. Hereinafter let's consider only the survey which has provided the materials for mapping after the required processing [1, 2].

### 3 Survey of the Moon and the related map products

The Moon was surveyed by the Soviet s/c of the "Luna" and "Zond" series and the USA s/c of the "Ranger", "Surveyor" and "Lunar Orbiter" series as well as from the "Apollo" manned s/c series. Though starting from 1959 the Moon was surveyed by more than 30 automatic and manned s/c in various modes, at the present time the lunar surface, as a whole, is presented on a map on the scale of 1:5,000,000

only. Map plotting on a larger scale was unfeasible on the basis of this survey. At the same time there are several dozens of maps on the scales smaller than 1:5,000,000. These general maps were produced in the USSR, the USA, Great Britain, Switzerland, Germany, Poland, etc. Maps on the mid scales are the maps of regions. Maps on large scales are the maps of local areas and of separate sites. Among the lunar map series there are maps for the Moon as a whole, for its visible and far sides, general topographic maps on the scales of 1:1,000,000 and up to 1:250,000 and at last large-scale maps on 1:100,000 and up to 1:5,000 scales, together with the topographic plans and topographic sketches on the scales of 1:1,000 and up to 1:20.

Along with the Lunar Complete Map on the scale of 1:5,000,000 (USSR) which turned to be the first map representing the whole surface of the Earth's natural satellite and ran several editions, and the Lunar Astronautical Chart on the scale of 1:1,000,000 (USA) for the visible side of the Moon plotted on the basis of the ground observations, the maps of the Lunar Orthophotomap series should also be noted. These maps are on the scale of 1:250,000 and cover about 20% of the lunar surface. They were plotted using the materials of survey from the "Apollo" series s/c. Topographic plans and sketches were produced for the landing sites of the automatic and manned s/c and along the "Lunokhod" routes either.

In 1994 the survey of the Moon was continued from the "Clementine" s/c from the orbit of the lunar polar satellite. This data is at last supposed to allow mapping the Moon as a whole on the scale of 1:1,000,000 [3].

#### **4 Survey of Mars and its moons. The related map products**

Mars was surveyed from flyby trajectories, from the orbits of the Martian artificial satellite and from the surface. The Soviet s/c of the "Mars" series surveyed only a small site in the neighborhood of the Nirgal vallis. The USA mission of surveying Mars turned to be sufficiently successful.

S/c of the "Mariner" series conducted survey in the flyby mode, "Mariner 9" and "Viking 1,2" – global survey from the orbit of the Martian artificial satellite. The landers of the two latter stations successfully performed soft landing on the planet's surface and transmitted the first surface panoramas. Due to the data from the "Viking" s/c the Martian surface has already been completely represented on the maps not only on the scale of 1:5,000,000 but on the scale of 1:2,000,000 either. In the first case the map consists of 30 sheets and for the second case it includes 138 sheets. Several general small-scale maps of Mars were published in the USA, the USSR, Switzerland and Great Britain. Regional maps of the planet are on the scales of 1:1,000,000 and 1:500,000. A series of photographic plans was plotted for the landing sites of the "Viking" s/c.

In addition to surveying Mars the "Mariner 9" and "Viking" s/c and later on the "Phobos" s/c performed a survey of the Martian moons – Phobos and Deimos. This resulted in the production of the first maps of the Phobos's surface on the scales of 1:200,000 and 1:100,000, and the sketch map of the Deimos's surface on the scale of 1:60,000. Because of non-uniformity of the original materials the relief represented on these maps requires updating. For the first time a triaxial ellipsoid was used as the reference surface since it is impossible to approximate Phobos by a sphere.

## **5 Survey of Venus and the related map products**

As it is known it is possible to survey Venus in the visible band only from the planet surface. The stations of the "Venera" series provided the first panoramas of the Venus's surface in this band. Then in 1978 "Pioneer-Venus" s/c fulfilled altimetry survey of the planet within the latitudes from +70° to -65°. Consequently a map on the scale of 1:50,000,000 with the contour interval of 1 km was produced. The "Venera 15, 16" stations carried out the survey of the northern hemisphere of Venus. From 1990 till 1994 the "Magellan" s/c performed global radar survey of the planet. In total four full observation cycles were performed. That will allow to map the planet on mid and large scales. Presently there is a map on the scale of 1:15,000,000 for Venus and on 1:5,000,000 – for the northern hemisphere produced on the basis of the materials from the "Venera" and "Pioneer-Venus" s/c. In addition there are photographic plans for the "Venera" s/c landing sites.

## **6 Survey of Mercury**

The "Mariner 10" s/c surveyed Mercury in 1974-75 during three flybys what made it possible to map 40% of the planet's surface on the scale of 1:5,000,000.

## **7 Survey of moons of the giant planets, asteroids and nucleus of comets**

The third decade of space survey is distinguished by starting surveying the moons of the giant planets and the nucleus of comets. Missions of the "Voyager" s/c series resulted in the images of the equatorial areas of the Galileo's moons of Jupiter, moons of Saturn, Uranus and Neptune. That allowed to map 30-50% of their surfaces on the scale of 1:5,000,000 in the Mercator projection. The surfaces of the next Jupiter's satellites: Amalthea, Io, Europa, Ganymed and Callisto were mapped. Among the Saturn's moons – Janus, Epimetheus, Mimas, Enceladus, Tethys, Dione, Rhea, Hyperion, Iapetus, Phoebe; the Uranus's moons – Puck, Miranda, Ariel, Umbriel, Titania, Oberon; the Neptune's moons – Triton were mapped either. The Halley's comet nucleus was mapped on the basis of the survey by the "Vega" and "Giotto" s/c in 1986. At last in the early 90s the "Galileo" s/c transmitted the first images of the Gaspra and Ida asteroids.

## **8 Cartographic studiness analysis**

Analysis of the cartographic studiness of the Solar system bodies (Table 1) shows that all the types of cartographic products including photographic maps and photographic plans, general and thematic maps, globes and various types of atlases. There are absolutely no cartographic data about the Pluto-Charon system.

The maps of the surfaces of the planets and their moons having been created by the present time allow to perform cartometric research, to determine characteristics of distribution of various types of relief, to reveal the correlation between global relief formations, etc. They play an important role when solving applied tasks and in particular when supporting space missions and scientific experiments.

Table 1: Cartographic studiness of the Solar system bodies

Type of production Celestial bodies	Images of celestial bodies	Topoplans	Maps		Atlases		Globes
			geograph.	thematic	photogr.	cartogr.	
Mercury <sup>x</sup>	+	-	+	+	+	+	-
Venus	+	+	+	+	-	+	+
Earth	+	+	+	+	+	+	+
Moon	+	+	+	+	+	+	+
Mars	+	+	+	+	+	+	+
Phobos	+	-	+	+	+	-	+
Deimos	+	-	+	-	+	-	-
Asteroids <sup>xx</sup>	+	-	+	-	-	-	-
Jupiter	+	-	-	-	-	-	-
Moons <sup>xx</sup>	+	-	+	+	-	-	-
Saturn	+	-	-	-	-	-	-
Moons <sup>xx</sup>	+	-	+	+	-	-	-
Uranus	+	-	-	-	-	-	-
Moons <sup>xx</sup>	+	-	+	+	-	-	-
Neptune	+	-	-	-	-	-	-
Moons <sup>xx</sup>	+	-	+	+	-	-	-
Pluto	+	-	-	-	-	-	-
Charon	+	-	-	-	-	-	-
Comet nuclei <sup>xx</sup>	+	-	+	+	-	-	-

<sup>x</sup> Not-complete area coverage

<sup>xx</sup> Separate bodies, not-complete area coverage

#### References

- [1] Atlas of the Terrestrial Planets and their Moons, M. MIIGAIK, 1992, 208 p.
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- [3] Davies M. Clementine and the Lunar Control Network. 30th COSPAR Scientific Assembly Hamburg, Germany, 1994, p. 53.
- [4] Duxbury T. Lunar Science from Clementine J.P.L. 30th COSPAR Scientific Assembly, Hamburg, Germany, 1994, p. 55.