CO-161

IO MAP FINAL VERSION

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1. HISTORICAL BACKGROUND

This map of Io is a continuation of the first series for multilingual maps of the Earth Group Planets and their moons. The multilingual map project was the first one which was carried in frames of Planetary Cartography Commission under ICA support since 1996. The nomenclature of relief features and their names is traditionally appropriated by International Astronomical Union (IAU) on Latin. It was proposed to give on maps a Latin version of names, and on the back of a map to place the corresponding information in 5 languages. This information, besides the terminology concerning relief forms, and their own names should include brief characteristics of a celestial body, data on surveying of a given body during space programs, and also the relativity figure accepted for it. The first series was made on the basis of Atlas for terrestrial group planets and their moons, published in Russia in 1992. Maps of a series contain the information in 5 languages, namely English, German, French, Spanish and Russian. Composition of maps is submitted by two hemispheres having the same size for all celestial bodies (exept Phobos and Deimos) and accordingly various scales (fractional and approximated). The shaded relief is introduced, that emphasizes its originality.

The first one of this map series was the Mars Map. Its scale was 1:25 000 000. Subsequently maps of Venus, the Earth's Moon, Mercury and the Mars satellites Phobos and Deimos were prepared following the same procedure.

It is necessary to underline that after a while this project began to develop in two directions: 1. Making the same map series, but with new groups of languages. 2. Dessiminating this idea for new groups of celestial bodies (giant-planets moons, asteroids).

Concerning the first direction the best results were obtained in Hungary under guidanse of Henrik Hargetai. Thanks his activity it was compiled and printed the series of the multilingual maps in such languages as Hungarian, Bulgarian, Czech, Polish and Chroatian pals English for comparison. As a next step there are ideas about some language groups from Asia and Africa, especially from Japan.

Also today it exists enough information for beginning of the next (second) stage of multilingual map project namely mapping of giant planets satellites. The multilingial map series of giant planets satellites and in the first line the map series of Jupiter Galileen moons (Jo, Europa, Ganimed and Callisto) is considered as a new phase of this project. At first it is prepared the map of Io. The compilation of its preliminary version was demonstrated and discussed during ICC24 meeting in Chile.

2. INTRODUCTION

It has to be noted that within the last years the interest in the celestial bodies far distant from the Earth has been increasing thanks to the more recent successful space flights like the Galileo and Cassini Projects. They yielded a lot of information about the Galilean Moons of Jupiter, the largest Saturn Moon Titan and many smaller moons of the giant planets. On the other hand, the average knowledge of the public about the physical properties, shapes and relief of these celestial bodies is still rather meagre. The Moscow discussion at the ICC 2007 made it clear that the international interest in such a map series can be considered sufficient.

It has been decided to proceed the same way as with first map series, i.e. to present a preliminary version of the Io Map in Lambert Azimuthal Equivalent Projection at a scale of 1: 14 000 000 at the ICC 2009 in Santiago de Chile and then to present the final version of the map in Paris. In Santiago was again some discussion of both the map contents and the collateral information. The main remark was about not enough impressive representation of some relief features. After this discussion we hope to produce a map of higher quality.

The preprint has a format of 55 cm x 84 cm, the two hemispheres having a diameter of 47 cm x 78 cm. In addition to the map proper, imprint information in five languages was printed under the two Io halves.

3. PRODUCTION BASIS

The current project is continuing the close scientific cooperation between the Moscow Sate University for Geodesy and Cartography (MIIGAiK) and the Institute for Cartography of the Dresden University of Technology (TUD). Since one main goal of the envisaged maps of this series was the high-accuracy

depiction of the overall relief, an adequate representation had to be envisaged. A "classical" relief representation, which was already used for the Earth Group Planet maps, has been chosen. But it was desided to replace a pencil-made manual hill-shading on a computer graphic tablet. It was prepared at MIIGAIK. It simulates a West illumination with an elevation angle equal/smaller 400. So far, this relief shading drawing seems to be the most impressive depiction of geomorphologic features of the entire moon: highlands and lowlands, mountains etc. are clearly perceivable. Thus, one can obtain a good impression of relief details of Io and, hence, simultaneously get an idea of its physiognomy as a whole. The overall quality, richness in detail and original size of the shading suggested the final map scale of 1: 14 000 000.

It has to be mentioned that the Io relief is very unusual and in many aspects different from the other celestial bodies of the Solar System. It is literally bursting with volcanoes that spew sulfurous plumes over 300 km high. One called Prometheus may have been active for at least 18 years!

When making the final map of Io the key point is rendering relief features. Io is a bright celestial body, its surface reflects 60% of incident light. Temperature of Io's surface in equatorial area in the daytime on the average is nearly –50°C. The atmosphere is extremely thin. Io has the most bright colors of all the Galileo's satellites. Its shape is almost a sphere, the size is a little larger than the Moon's (radius 1819 km). By its powerful gravitation, Jupiter creates two tidal bulges on the Io's surface which breaks the rotation of the satellite. Therefore its orbital period, keeping one face nearly pointed toward Jupiter is 42.5 hours. Like the other Galilean satellites of Jupiter and the Earth's Moon, Io rotates synchronously with its orbital period. The surface of the satellite is variagated in color. The relief is generally flat. By the color of the soil, three main types of flats are distinguiched: orange, white and brown.

Mapping the satellite requires that some features be taken into account: as a rule, when compiling a map of the Earth group (the Moon, Mercury and Mars), the amount of impact craters covering a given territory helped to determine the whole stratigraphic and sometimes age correlation. On the Io surface, continuous layers of volcanic deposits cover almost all impact craters. Besides, as a rule, when mapping planetary bodies, stereopairs of images are used, but there are not many stereopairs for Io.

Volcanic ejecta change the appearance of Io's surface on a daily basis and sulfurous material that escapes the moon form a gigantic torus of gas circling Jupiter. Nestled inside Jupiter's magnetosphere, the "Io torus" is enormous. With a diameter the size of Io's orbit it spans 844 thousand km and has an important impact on Jupiter's magnetic environment. As Io moves along its orbit and through this magnetized plasma torus, a huge electrical current flows between Io and Jupiter. Carrying about 2 trillion watts of power, it's the biggest DC electrical circuit in the solar system. The dozens of active volcanoes on Io result from 100 meter high tides raised in its otherwise solid surface by nearby Jupiter and the other Galilean satellites. Although this process is fairly well understood, much of Io's forbidding environment remains a mystery.

The main type of relief on Io is volcanic plains, almost without impact craters exceeding 2 km, but complicated by more than 100 volcanic craters which are more than 25 km in diameter. Most of the craters are at low latitudes, but some are also discovered at circumpolar latitudes (caldera Inti 69°degree S, longitude350°west). In the plains, there also are benches like lava streams, hill-like elevations, depressions of irregular form.

Friable formations on the Io surface are probably light ashes consisting of sulfur coming from underneath through multiple volcanic craters.

It is necessary to remember about relief dynamics as well. For example changes in patera Pilan over 5 months, namely, a new dark spot of 400 km in diameter round patera Pilan.

Io craters have several special characteristics and they are generally not like craters known from other planets and their moons. There are also many pateras. The different colours of larger as well as smaller areas are very diffucult to represent because of active processes which change the relief situation. The same applies to the fluctus and their origins. The eruptive centres also represent intersting features.

4. MAP PRODUCTION

Based on the decision on the final map scale, which resulted in a diameter of 39 cm of the two hemispheres, a first general map layout has been made. It became clear soon that it would not be possible to print all the collateral information on the front side but to put it into text blocks in the back.

For the production process digital reprographic methods were applied, aiming at an equivalent of a repro screen of 54 points/cm for the relief shading original. A few attempts were made in order to optimise the reproduction of the relief representation, in particular to balance between the bright tones of the highlands and the darker tones of the lowlands.

The coordinate grid of the map whose geometry is based on the Transversal Equivalent Azimuth Projection of Lambert shows every twentieth parallel and meridian.

The lettering is kept in black and displays different fonts: for pateras 7 point Arial, capital letters; for mountain ranges 7 point Arial, italic, capital letters; for plains 7 point Arial, wide spacing, capital letters. Thus it gives explanations on all known and named geographic features. The type of lettering allows to deduce the geomorphologic categories.

Below the title "Io", between the two hemispheres, one finds the astronomical/astrological symbol for this planet.

For the printing several colors have been used. All letterings have been printed in black. The background outside the actual map-field is kept in "night-green", representing the darkness of the outer space and using a special printing ink.

The paper format of the map is 55 cm x 84 cm, the format of the printed area being 47 cm x 78 cm which corresponds to the hemisphere diameter. The printed area in the back amounts to 43 cm x 81.5 cm. This is the size of a frame which contains explanatory texts about the map and the planet.

The front side comprehends imprint information about map designer, printer, editor, cartogra-phers and consultants.

The back displays geophysical information about Io like density, radius, volume, albedo, orbit inclination , rotation period, and many more (Figure 1).

<table width="200" cellspacing="1" cellpadding="1" border="1" align="left" summary="English Mass: 8.94x1022 g Density: 3.55 g cm 3 Reference Datum: sphere Equatorial Radius: 1815 km Surface: 4.137 x 107 km 2 Volume: 2.503x 1010 km 3 Gravitational Acceleration: at the Equator: 1.79 m s -2 Axial Inclination: 0.00o Orbit Inclination: 0.04°. Average orbital speed: 17.34 km s -1 Orbital Period: 1.77 days. Rotation Period: 1.77 days Average Surface Temperature: -143°C. Albedo: 0.061 Maximum Brigthness: 5.02 mag">

English

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Figure 1. Geophysical background information about Io.

Io Sondes:
(having imaged Io)
1973 Pioneer 10 (USA)
1974 Pioneer 11 (USA)
1979 Voyager 1 (USA)
1979 Voyager 2 (USA)
1995-2003 Galileo (USA)

Figure 2. Imaging Io sondes.

Besides a list of imaging Io sondes (Figure 2), a glossary of "Io-morphologic" terms like patera, eruptive centre etc. completes the backside information (Figure 3).

<table height="23" width="200" cellspacing="1" cellpadding="1" border="1" align="left" summary="Relief Forms of the Io: Catena: crater chain of closely spaced depressions Fluctus: lava or mud flow Mensa: table mountain Montes: mountain range or mountain massif Regio: large region distinguished from the neighboring Patera: a crater of irregular form or complex crater with toothed edges Planum: plain, plateau Tholus: isolated small domelike mountain or hill Eruptive center: active volcanic center active volcanic center">
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edges
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Figure 3. Glossery of morphological terms occuring in the Io Map.
All this information is (from left to the right) given in English, German, French, Spanish and Russian (in cyrillic letters), each text block being printed in a light-grey, screened, elongate box of 14.6 cm x 39.8 cm.
The final version of Io map is represented on Fig. 4

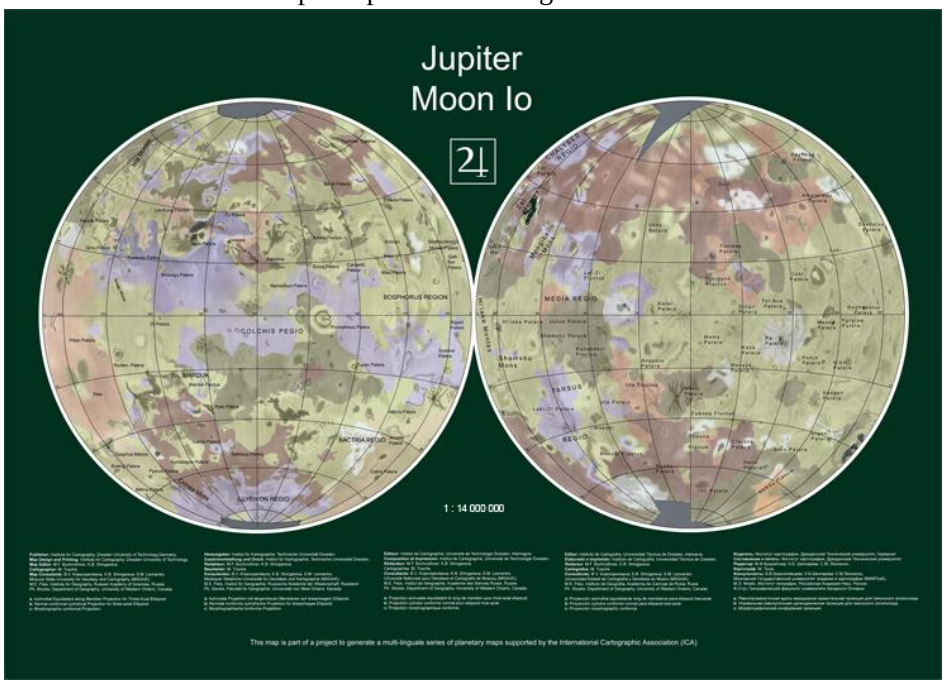

Fig. 4. The final version of Io map is represented on

5. CONCLUDING REMARKS

With all its features like easy-to-perceive relief representation, complete landing sites, glossary of morphological terms, and its five-language multilingualism the described Io Map is unique world-wide. The next one in the series of envisaged planetary maps will be a map of Europa, which will also be produced in close cooperation between TUD and MIIGAiK. Although only fly-by missions have visited the moon, the intriguing characteristics of Europa have led to several ambitious exploration proposals. The Galileo mission, launched in 1989, provided the bulk of current data on Europa. A new mission to Jupiter's icy moons, the Europa Jupiter System Mission (EJSM), is proposed for a launch in 2020. Conjecture on extraterrestrial life has ensured a high profile for the moon and has led to steady lobbying for future missions.