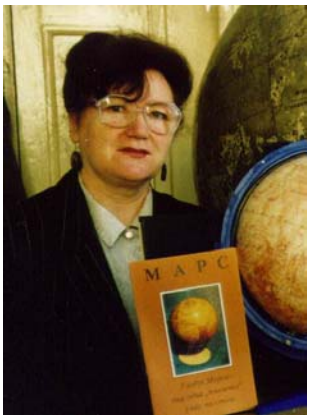

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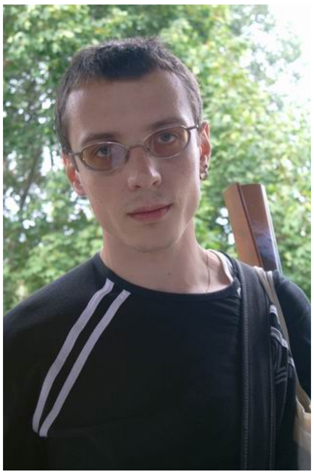

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THE LUNAR SUBPOLAR RELIEF MAP: THE WAYS AND TECHNIQUES OF COMPILING AND USING

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Introduction. During next years it is planned renewing spacecraft exploration of the Moon. For example, in August 2007 Japan Aerospace Exploration Agency plans launching the Moon explorer SELENE with 14 science instruments on board including the high-resolution stereo imager Terrain Camera (TC). The height resolution of Digital Terrain Model (DTM) produced from the TC stereo data is expected to be 20m or better. And it will be the first terrain model covers the entire surface of the Moon with 10m spatial resolution, and used for the various fields of lunar sciences. It is planned to publish the global TC Ortho map to be produced by mosaic of TC data [1]. At the same time NASA's Robotic Lunar Exploration Program (RLEP) will execute a series of robotic missions that will pave the way for eventual permanent human presence on the Moon. The Lunar Reconnaissance Orbiter (LRO) is first in this series of RLEP missions, and plans to launch in October of 2008 for at least one year of operation [2]. LRO will employ six individual instruments to produce accurate maps and high resolution images of future landing sites, to assess potential lunar resources, and to characterize the radiation environment.

The most interesting lunar region for this research is the Lunar South Pole area because it is suggested there are deep flaws with water ice never being under sunlight and being situated into the shaded craters of this territory. Owing to processing of spacecraft Clementine stereoimages [3] we got the database of the Lunar South Pole region including latitudes, longitudes and heights of 4,5 million points for this area. The morphometric investigations of the Lunar South Pole region surface have been fulfilled using our database. The detailed profiles of this area created by us describe the features of this region surface with the high resolution up to 100 meters.

Techniques of investigations. Clementine data is the only available one for the whole lunar surface today. In 2000 A. Cook et.al. had compiled Digital Elevation Model (DEM) on the base of Clementine 1 km/pixel stereoimages with the relative height resolution of about 100 m [3]. The absolute errors of heights at this model make up ± 0,7 km for the whole Lunar South Subpolar region, but errors in areas being to the south from parallel 79° can make up ± 1 km.

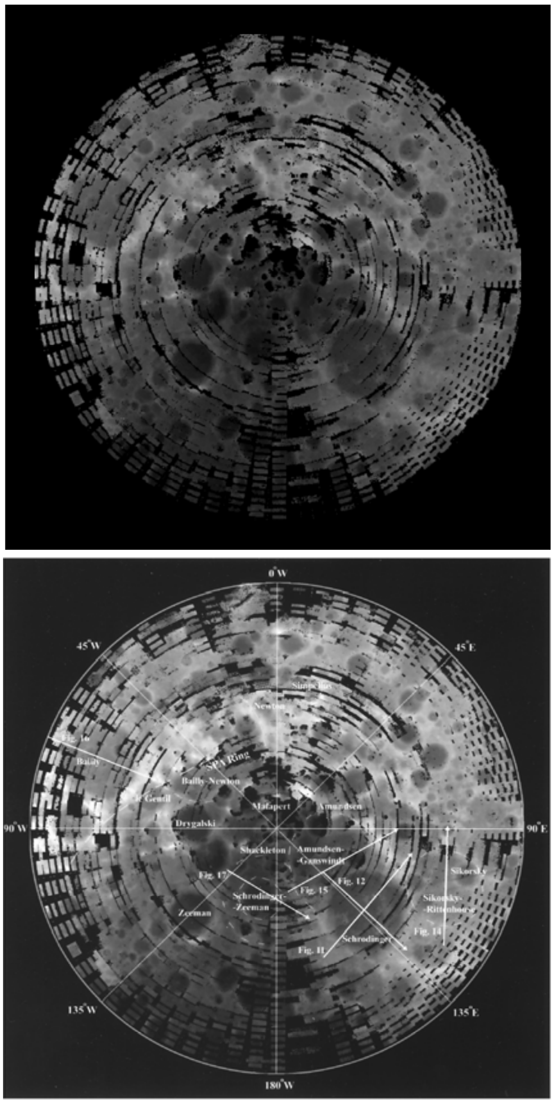

Fig.1 Raster image of South Lunar Subpolar region (latitudes from -60° to -90°) and the same image with coordinate net [3].

The heights of DEM having compiled by A. Cook et.al. [3] were counted from the mean radius of the Moon of 1737,4 km. According to our investigations fulfilled on the base of different height level areas measuring at the Hypsometric map of the Moon having been created using heights of 64 800 one degree trapeziums, the mean radius of the Moon is equal to 1737,577 km [4].

To create Lunar Subpolar relief map the authors obtained heights from the A. Cook et.al. raster image of South Lunar Subpolar region (latitudes from -60° to -90°) [3] being constructed in stereographic projection. To reference this raster image the same one with coordinate net was used (fig.1).

After the raster was referenced and exported to GRID-format, the next step was the obtaining database with the help of ArcView v3.3 script grid2xyz.avx [5] so that each database line was corresponded to each image pixel. The attributes of each line were coordinates of pixel center and its brightness. The size of database obtained was more than 250 megabytes or more than 6 millions points.

After editing database that is the removing of wrong lines, where brightness was equal 0 (black areas with data lacking) and 255 (the white raster frame) the total amount of points became equal 4,5 millions. During this stage of processing information some problems being corresponded to the origin raster appeared. There are the transitional zones situated on the border between real lunar surface and black areas with data lacked. The thickness of this zone is about 3 – 4 pixel (fig.2). At this figure one can see that the real lunar surface (on the right) and black area (on the left) are divided by area consisting of pixels becoming brighter gradually. The values of pixel brightness GIS-program gives the point attributes are not corresponded to real values of the lunar surface. To remove these points from the database, the buffer zones were created round of every black area.

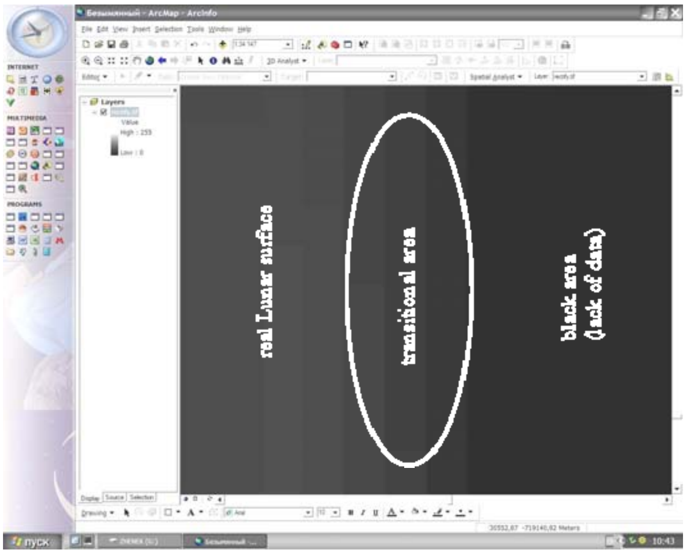

Fig.2 Lunar surface being at largest scale in the window of program ArcGIS.

After that the database had been made and edited we created the shape-file to comlile the Digital Realief Model of Lunar South Pole region. For that point attributes of the database had been visualized and converted to the shape-file in stereographic projection with the help of ArcGIS v9.0 (fig.3).

Then the values of brightness were counted into values of height using the next equation:

$\boxed{h = 75 \cdot I - 8700}$, ***h*** – point height, ***I*** – brightness.

The shape-file we had got was opened in the new ArcGIS frame in geographical coordinate system. As we were in the need of projected (spherical) coordinates in degrees to add them into our database instead of geographical coordinates in meters, the latter was counted into spherical ones.

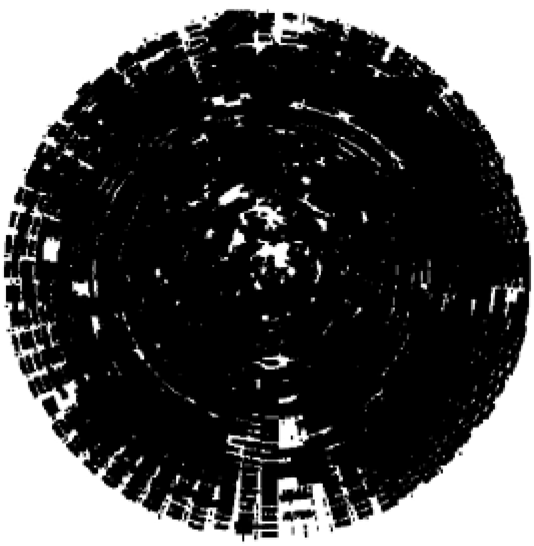

Fig.3 The point shape-file of the Lunar South Subpolar region in stereographic projection

The next stages being necessary to compile the Lunar Subpolar relief map are the joining Clementine laser altimeter data to data obtained and counting them correlation, constructing of contours, adding the shaded relief and the final map compiling. In this article we described map creation of the Lunar South Pole region, but as well it is proposed to create the relief map of the Lunar North Pole region. It is being fulfilled today and the final result of our work will be the Lunar Subpolar relief map with contours. But even now we can fulfill the different morphometric investigations of this interesting region of the Moon.

Using the data obtained. Morphometric investigations. Based on database obtained height profiles of the Lunar South Pole region along 0°, 90°, 180° and –90° meridians were created. The height profiles of some lunar craters including crater Schrödinger (latitude -75.2°, longitude 133.8°, diameter 320 km) were created too. These profiles show and characterize the height levels of the lunar craters and subpolar relief in detail (up to 100 m).

In general height profile makes clear imagination of surface and the main relief features. For instance, profile we created along 0° meridian (fig.4) characterizes the relief of the lunar nearside from -70° to -84° parallels. One can see the difference of heights from

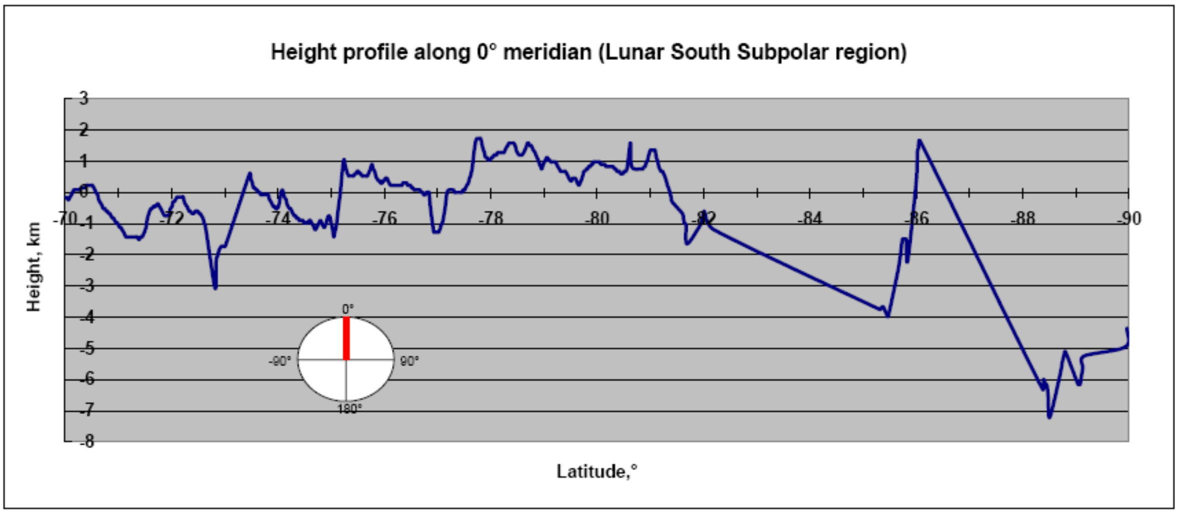

Fig.4 Height profile along 0° meridian (Lunar South Subpolar region)

+1,7 km to -3 km. Further to the South Pole there are sudden falling up to -7 km and high mountain being at -86° parallel. The relative high of this mountain North slope is equal 5,7 km and the relative high of the South one is 7,3 km.

The height profile of crater Schrödinger along -74° parallel is shown here for instance too. This crater has smoothed rim, terrace and faults, the big external rim, ridge and a lot of hills at the rough bottom. The eastern mound has height of 1,3 km and the western one has height -2,5 km, that is crater Schrödinger has asymmetric rims. The internal ring of the ridges has raised rims. The relative height of this internal ring is equal 1 – 1,5 km.

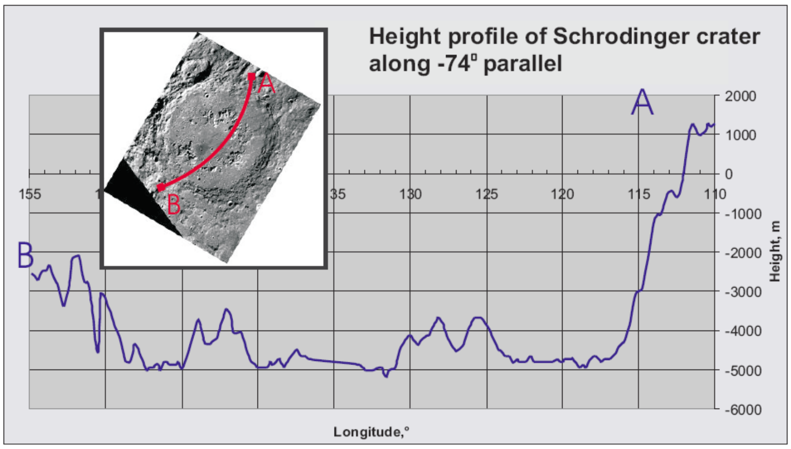

Fig.5 Height profile of crater Schrödinger

Authors [3] noticed, that indefinites of absolute subpolar heights fixing are still very essential. For example, in paper [6] it is proposed positive heights. For the rim of crater Shakleton being near the South Pole of the Moon radar data from the Earth surface [7] and authors [8] as well define positive heights of 1,6 km and 3±1 km accordingly while in papers [3] and [9] crater Shakleton has negative heights of -2,9 km и -3,9 km. That is why we decided to compare the absolute heights from Rosiek et.al. Lunar map [10] with the absolute heights of our map. The comparing was fulfilled using the height profiles along -90° and 90° meridians.

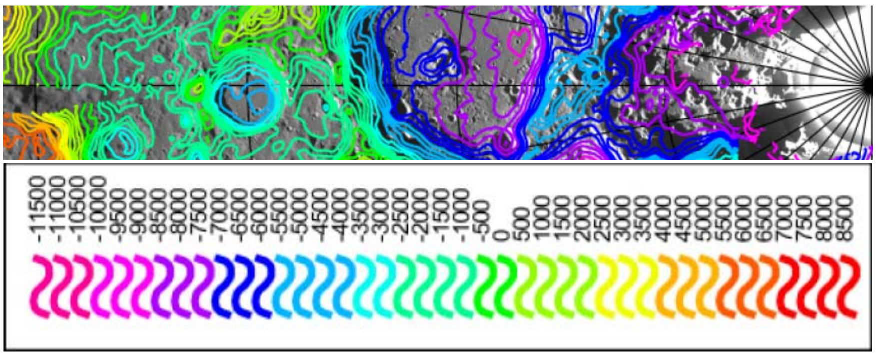

Fig.6 The part of the map [10] along meridian -90° and the height scale

Paper [10] provides synopsis of a project to collect digital elevation models (DEM) from Clementine imagery. Topographic data were derived from overlapping nadir images collected by Clementine. This technique used stereo models formed by the imagery side lap of images from adjacent orbits. A relative elevation was derived at 1 km spacing and then the digital elevation model (DEM) was adjusted to fit the altimetry data or previously collected photogrammetric topographic data and contour lines for the lunar south pole were constructed (fragment of this map is shown at fig.6) [10].

The authors of the paper [10] marks: “This data is still being evaluated and edited. When compared to the Clementine altimetry data the data in figure 11 tends to be 1- 2 km

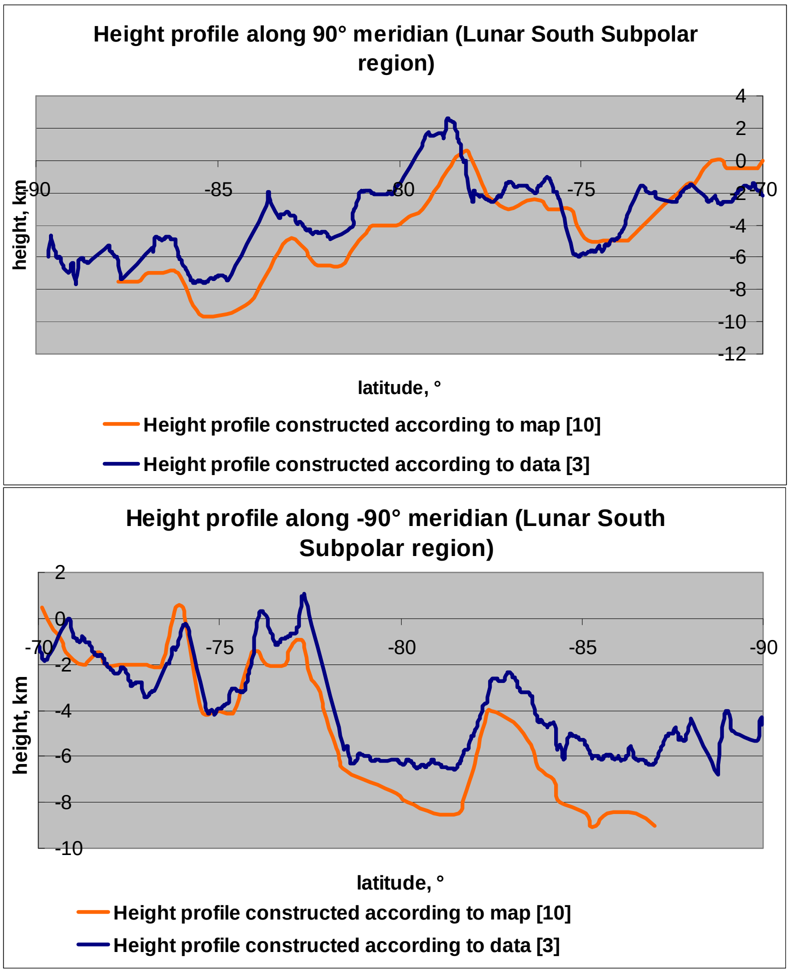

Fig.7 Height profiles along -90° and 90° meridians constructed according to map [10] and data [1]

higher at the edge, 65°S. When compared to Tony Cook's data the data in figure 11 tends to be 1- 2 km lower at the pole, 90°S. We are working on adapting the ISIS program EQUALIZE to adjust the errors."

The comparison of height profiles (fig.7) constructed using our data with the profiles constructed using the map at fig.6 [10] showed the differences being of about 1 – 2 km having already noticed by authors [10] themselves.

Conclusions. Based on processing of the Digital Elevation Model (DEM) created using the Clementine data [3] we compile the Lunar South Pole area database including latitudes, longitudes and heights for more than 4,5 millions points. At this moment we are compiling the Lunar South Pole region hypsometric map using this database. The next step of our work is the creation of the whole lunar surface hypsometric map. This map is planned to include in the Terrestrial hypsometric map series. For this series the Mars hypsometric map has been already published and the Venus hypsometric map is preparing for issue. However, using database we had obtained it became possible to fulfill the morphometric researches of the Lunar Subpolar relief even now. The detailed height profiles of different surface areas were constructed with the high resolution up to 100 m. The comparison of the profiles created using the data [3] and map [10] showed, that relief of South Subpolar region of the Moon is represented more detailed in paper [3], while absolute heights are differed from 1 to 2 km.

Acknowledgements. We would like to thank Maxim Dubinin (http://gis-lab.info) for help, support and useful discussion.

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