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Addendum 1

To the problem concerning the Lunar Crater Designation System

TO THE PROBLEM, CONCERNING THE LUNAR CRATER DESIGNATION SYSTEM

1. The statement of the question

In the lunar mapping one often met with the necessity of designation of the characteristical relief forms on the lunar middle and large scale maps, made in particular, on the base of space photographs. The same necessity will inevitably occur in future both at the new mapping and at the compiling of the more detailed catalogues of the lunar control points. Unfortunately we have to state so far the absence of uniform designation system for nameless relief forms neither for the visible nor all the more for the far side of the Moon, though it had been made some attempts.

In this paper we consider the questions connected with the selection of the objects to be given proper names with the adoption of the common system of the crater forms designation. We define the lunar nomenclature as the classification of the lunar relief forms in total with the adopted list of names of some large objects and uniform system of designations for the other objects. Such a conception differs from that in the terrestrial cartography, but carries on the historical traditions in the lunar mapping.

2. Some origin data

There is no necessity at present in existing names of craters on the visible side to be revised or in the giving new ones. Considering this state as correct, we shall use data for the visible side as origin.

There are about 600 craters on the visible side of the Moon designated. The distribution of the craters with proper names for the visible side is shown on the chart-scheme (fig.1). The named craters on the highlands have an average density 3 to 90.000 km^2 (10^ox10^o in the equatorial zone), an average diameter of named formations being more than 25 km. The formations of the less diameter till some kilometers (D = 5 ÷ 10 km) were often named on the maria, average density of them being 1 crater to 90.000 km^2.

The analysis shows that there is a group of large craters on the visible side without proper names. For example, according to our counting about 300 craters, 50 km and more in the diameter, are not given proper names.

3. Objects on the far side of the Moon to be named

The project of selecting craters to be named on the far side of the Moon worked out at the Institute for Space Researches has the next main principles:

I. The even distribution of the craters to be named regardless of regional formations (maria, mountain-range, largest craters etc.) designation.

II. The different criterions for the diameters of the named craters in the regions with different crater density (for example, the diameter of named craters for maria plains would be essentially less than for the highlands).

III. The regard for location of craters to be named and their role for the orientation on the adjacent country.

Assuming the total number of named craters both on the highlands and on the maria for the far side of the Moon to be approximately the same as for the visible side, there were calculated an area of a parcel, which one named crater falls on.

$$\sigma = \frac{1/2\ S}{k}\ ;$$

k = number of named craters on the visible side of the Moon

$\sigma \approx 32{,}000\ km^2$

S = a surface area of a sphere, radius 1738 km.

The sizes of this parcel for the equatorial belt are $6^\circ x 6^\circ$.

Since the nomenclature sheet division on the far side surface with the $16^\circ x 20^\circ$ sheets in the zone from the equator to the parallels $\pm$ 48° (shown fig. 2) has been worked out by this time, the similar area has a parcel corresponding to 1/4 of this list ($8^\circ x 10^\circ$), i.e. $65{,}000\ km^2$.

In this case there will be in average 2 named craters in each parcel. The total number of craters named on the far side of the Moon will be approximately the same as on the visible side. A parcel of lunar surface limited by meridians and parallels no less than I named crater within we shall name b l o c k.

Blocks dimensions of $8^\circ x 10^\circ$ stay invariable for only million map sheets, situated between parallels $\pm$ 48°. In accordance with the nomencalture sheet division proposed the sheets of 1,000,000 scale map in the belt between 48° and 64° by latitude are doubled and between 64° and 80° by

latitude are trebled, block being 1/4 of doubled or trebled sheet. The polar caps beginning from 80° parallel regard as single sheets of a I:I,000,000 scale map, block being also 1/4 of such sheet. There are 280 blocks for each hemisphere in result. The block placing on the lunar surface (for the hemisphere) is presented on the scheme 3 (fig.3).

The project of the named craters distribution taking into consideration these reasons was given an abbreviated name EDP (Even Distribution Project). It was submitted for consideration to the Working Group on the lunar nomenclature of Comission 17 of IAU and was mainly approved. The working group intends to present at the next General Assembly of IAU the list of named formations, containing about 540 objects (chart-scheme, fig.4) for the approval. According to this scheme 13 blocks of the far side are not given no one crater designated.

We consider the list of named craters should be continued in accordance with tradition, made the Moon a pantheon of human glory and on the other hand with the demands of the lunar mapping. It led to compiling of the table including coordinates of craters to be named in future. At the beginning of this table there are 13 craters according to the number of the nameless blocks. The craters dimensions are not large as a rule, but these craters are situated in regions where large formations are known to be absent. They are marked on the scheme by asterisk.

Then we enumerate the craters which designations would make the named craters distribution more even. They are

marked on the scheme (fig.4).

4. Proposals on a uniform system of designation for crater forms

The assignment of names to more than 500 craters corresponds to the interests of cartography only in small-scale mapping. At the compiling the maps of I:100,000 scale and larger there would not be any named object on the greater majority of the sheets; it would make the work with the map difficult, particularly considering the monotony of the lunar relief. Therefore the question of introducing a system of symbols (designations) for lunar craters that did not get a proper name becomes actual.

A system of designation accepted for the visible hemisphere has been introduced by Bear and Mädler. It has been used in compiling the LAC map of I:I,000,000 scale as well as the series of Ranger maps (scales I:I,000,000; I:500,000; I:100,000; I:10,000; I:I,000). Craters on the maps up to the scale I:I,000 were indicated by a consecutive addition of Latin letters to the name of the nearest large craters like for instance:

BONPLAND

Bonpland A	Bonpland C
" AA, AC ...	CC, CD ...
ACD ...	CDE ...
ACDE ...	CDEF ...

and so forth.

In our opinion the main short coming of this system is that the indexes do not convey any additional information, there is no gradation for the size of the objects and maximum distances to the objects when changing from one group of symbols to the other. In each actual case the designations are arbitrarily grouped around the crater with a proper name.

A good point of the system is its virtually unlimited possibilities in designating all the formations, the smallest included. Admittedly, it should be noted here as well that by increasing the number of the gradations the recording and the reading become complicated. For the fourth gradation, for example, the designation will look something like:

Bonpland CDEF ... etc.

Critical remarks regarding this system have been voiced by some authors including Arthur [I].

To eliminate the defects of the system described it should be slightly modified. It would be advisible, for instance, to establish the dimensions of the formations for each gradation and the maximum "radius of action" of the named craters, thus introducing a certain order in the grouping and supplying the designations introduced with the additional information. Such an approach, however, does not exhaust all the possibilities of the designations system.

Originally we had an idea to associate for large scale

maps the additional index with the nomenclature of the map sheet. This had to be given up, however, because possible grid displacements for a sheet of a large scale map could prove to be too markable.

More convinient is the establishment of boundaries for a certain parcel according to a formal geometrical feature. Meridians and parallels could be used as such boundary lines. Generally speaking there are no distinctly expressed boundaries of a regional character on the Moon and any limitation by distance will be to a certain extent conditional.

It is possible to give a number of arguments in favour of numerical indexes instead of those in letters. First of all, under the same conditions numerical symbols convey additionally quantative information; secondly, contrary to various alphabets they are understood in the same way internationally; thirdly, letter symbols of the Latin alphabet can be more successfully used later in elaborating the system of designations like, for instance, to characterizing the relief forms by shape, extent of destruction (classes A, B, C etc.) and so on.

The system of designations proposed by us refers to the craters only. As to the other morfological forms, nothing universal can be yet suggested for them, as far as we still have insufficient data on their distribution by size and their location in space.

Let us take the above block-parcel of the surface limited by meridians and parallels for a unit area. In each

block the number of craters with proper names will vary from I to 5. An exeption are 13 blocks without large cratres, where formations less than 25 km in diameter should be given names.

As it was noted above the system of designations is developed in the limits of the block. That is why the next step should be the examination of the statistical distribution of the craters in dependence on their diameters within the block. Let us find such limits on D (diameter) at which the number of craters of every following group should increase in an order.

The dependence of craters number upon their diameters given, for example , on Ranger materials [2] is described by the formulae:

$$N = 10^{10} C\ D^{-2}, \quad C = 1,4 \qquad (2)$$

The statistical data given for 1×10^6 km^2 area. The area of the block (~ 65,000 km^2) is about 15 times less. Hence for the block it will be :

$$N = 10^9 D^{-2}_m \qquad (3)$$

therefore for the calculations within the block we shall use the following expression for D:

$$D = \sqrt{\frac{10^9}{N}} \qquad (4)$$

Putting N correspondingly equal to 10^1, 10^2, 10^3, 10^4, 10^5, we receive the following limiting crater diameters: 10 km, 3 km, 1 km, 0,3 km, 0,1 km.

Formulae (2) is insufficient for the large formations, therefore first two boundary diameters - 25 km and 5 km were

set in result of direct counting of craters made into all blocks. The rest limiting crater diameters should be stated in round numbers in the interests of the uniformity of the designation system introduced and of the future cartographical generalization. There were adopted the following limiting crater diameters in result: 25 km, 5 km, 1 km, 0.5 km, 0.1 km. In accordance with crater sizes their division in groups has been made as follows:

group I - craters with $D \geqslant 25$ km

" II - " $25 \text{ km} > D \geqslant 5$ km

" III - " $5 \text{ km} > D \geqslant 1$ km

" IV - " $1 \text{ km} > D \geqslant 0.5$ km

" V - " $0.5 \text{ km} > D \geqslant 0.1$ km

In this for the first three groups the counting gave in average

for the I group - 7 craters in block

" II " - 21 " "

" III " -213 " "

i.e. the changing of craters number in an order is kept.

The direct counting in blocks at the groups shown above, were guided by maps and atlases at our disposal (fig. 3 a,b,c):

It has been used

for the visible hemisphere	for the far hemisphere
Lunar Astronautical Chart (LAC) I:I,000,000	Lunar Planning Chart (LPC) I:2,500,000

Rectified Lunar Atlas (RLA) I:3,500,000	Lunar Farside Chart (LFC-I) I:5,000,000

It proved to be possible to make the counting for the following groups:

	LAC	RLA	LPC	LFC-I
group I	+	+	+	+
" II	+	+	+	+
" III	+	-	. +x/.	-
" IV	-	-	-	-
" V	-	-	-	-

x/. crater diameters 5 ÷ 2 km.

According to the table I. and II, groups have sufficient material for the counting; III. group having more material for the visible hemisphere than for the far one. As regards to the craters of IV. and V. groups they are possible to be judged about by the statistical counting on the visible side.

It should be noted, that only for one case - crater Copernicus - N for the III. group proved to be more than it was supposed. As it will be shown below our system of designations will be suitable for this block too.

According to the system proposed one crater situated nearer to the center of the block is selected out of those in the block which have proper names. The probable coordinates' grid displacements are within 5' for the visible side.

Therefore, the center of the crater giving its name to the block must be moved from the block boundaries at a distance of not less than 5'. For the far side of the Moon it should be possible to use the same rule after the control to have been estimated.

The system of designations for all the smaller craters in the block with regard to group division should look like this x/.:

Block - Miln	group	I. Miln I, ...	xx xx/.
	"	II. Miln 0I, ...	99
	"	III. Miln 00I, ...	999
	"	IV. Miln 000I, ...	9999
	"	V. Miln 0000I, ...	99999

As it was mentioned the craters number of III. group in block 112 included the larger part of Copernicus rim, preceeds 999. As far as this block will be assigned by the name of the other crater situated not far from block center, namely Stadius, and the craters on the external wall of Copernicus rim at the distance of 1/5 their diameter will be regarded to Copernicus, the system is suitable for this block too.

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x/. The formations situated within the crater, included in the block with the other name, or on its rim are given this crater's name when using this system of designations.

xx/. Designations with Roman numerals come out of the common system. It was done with a view to mark out the formations of I. group to be given proper names in future.

x/. By this case the external rim boundary is defined as 1/5 of crater diameter 4.

Let us consider the example for the illustration (fig. 5a,b; 6a,b; 7a,b). As an experimental parcel it was selected the block 166 comprised the area to be photographed by Ranger VII. There are the maps of I:I,000,000; I:500,000; I:100,000 and I:10,000 scale for this area due to Ranger materials. We use for example all these maps, exept that of I:500,000.

Firstly on the I:I,000,000 sheet it was shown the boundaries of block 166 (fig. 5a) which was given a proper name. The block comprised 4 craters with the proper names - Bonpland, Parry, Opelt and Guericke. However, only one of them - Guericke - is situated near to the center of the block. Therefore it was given the name Guericke. Then all the craters attributed to the groups I, II, III were numerated in the block according to the system proposed. The numeration was carried out on the line, the step (wideness of the line) changing in dependence upon the group. For the I. and II. groups this step was 2° and correspondingly 0.5° for III. group. This step was selected taking into consideration to have no more than 20-25 formations of the given group in the line. For the IV. group the step 10' was accepted, for V. group - the step being I'. Such a numeration is shown on the block parcel in the I:100,000 and I:10,000 (fig. 6a, 7a).

Then on the other copy of I:1,000,000 map sheet (fig.5b) there were transferred all the formations numbers of I. and II. group and selectively those of III. group, when the formations of two former groups were absent. The numbers of

all the craters of I., II. and III. groups and selectively of IV. group were transferred in the I:100,000 (fig. 6b), and those of group V. in I:10,000 (fig. 7b).

The formations situated on the floor and rim of Bonpland , Opelt and Parry were designated according to the same system with regard to extent of external rim boundary till 1/5 of its diameter.

We consider the symbols in numerical system of designation to convey an additional information in comparison with lettering one. For example, the designation Miln 0153 should be read in such a way : the crater is at the distance of less than 350 km from crater Miln, diameter within 1 + 0.5 km, there are no less than 153 similar craters on the area about 65,000 km^2.

Introducing the dependence of names on objects' dimensions the system proposed will also facilitate the generalization of cartographical material at the scale changing. Besides it is more regulated and demonstrative than lettering system. At the same time unlike the visible side, the figure system for the far side is not traditional. As far as the extending of the nomenclature on the far side of the Moon is a question of the future it seems advisible to us to turn to the numerical system at once. The analogical system can be used in principle for the visible side if we refuse from the traditional lettering designations.

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