VIII INTERNATIONAL CARTOGRAPHIC CONFERENCE
USSR, MOSCOW, AUGUST, 1976

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COMPILING A SERIES OF CHARTS OF PHYSICAL PROPERTIES OF LUNAR SURFACE ON A COMMON MATHEMATICAL BASIS

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The study of the Moon by means of space facilities will continue yet for a long time to be of local nature. Correspondingly, the problems involved in the choice of the areas most promising for research are still quite urgent. The present state of the knowledge about lunar interior and surface must be considered in complex. As revealed by experience, an all-round analysis of the various physical characteristics permits the scientifically most interesting regions to be pointed out. An effective method for undertaking such an analysis proves to be the complex thematic cartography. With its aid it is possible to reveal correlations both between physical properties of lunar surface and between them and the chemico-mineralogical composition of lunar rocks, as well as certain specificities of the Moon's interior structure.

Unfortunately, the vast materials of ground and space studies of the Moon, which could be used for a complex analysis of the properties of lunar environment, are pretty scattered. In particular, individual thematic charts are compiled to widely different scales, on a mathematical basis of varying degree of accuracy. Moreover, their special details dail, as a rule, to be tied to the real relief. These features make difficult comparison of data and their joint interpretation. Accordingly, it appears practicable to undertake a compilation of a series of thematic charts of the Moon - geophysical, geologic-morphological, charts showing physical properties of lunar surface to one and the same scale and on a common mathematical basis, which would, moreover, contain information on surface relief.

Members of the Institute of Space Research, USSR Academy of Sciences, with participation of undergraduate students from the Moscow Institute of Engineers for Geodesy, Aerial Photography and Cartography have undertaken the compilation of a series of charts and chart-schemes of physical properties of lunar surface on a common mathematical basis.

Used as a basis was the "Moon Outline Map" to 1:10 000 000 scale prepared at the Institute. The map has been compiled in transverse azimuthal equidistant Postel's projection which is notable for convenient combination of lineal and angular distortions. This map was compiled specially as a standard basis for small-scale thematic cartography of the Moon /1/. The map is in the form of two hemispheres. This arrangement reflects the natural division of the Moon into a visible and reverse hemisphere and permits the sheet of the visible hemisphere to be used separately, since a great number of data are available for this territory alone.

The "Moon Outline Map" was being compiled from the data contained in modern photographic atlases and maps of the Moon. It shows the largest elements of relief, as well as those that serve as good reference points in observations from the Earth. Shown in the map at continental areas are all craters over 100 km in diameter. Craters of lesser diameter are not shown, unless they happen to be characteristic marks. Shown on marine areas are all craters over 50 km in diameter, as well as a few smaller craters-landmarks. Ridges, steps, furrows, valleys and chains of craters are conveyed by conventional signs; marine areas are made prominent by shading.

In compiling the map, use was made of practically all lunar photographic materials of corresponding scales available in the USSR. The boundaries of marine areas in the visible hemisphere have been specified according to geological maps. Shown unambiguously for the first time are the marine areas on the reverse side and in the boundary zones of the visible side. All this, along with the selenographic grid drawn through 10°, provides for accurate fixation of thematic contents.

By today the materials of Soviet and foreign observatories have been used to compile the following charts and chart-schemes for the Moon's visible hemisphere:

1. "The chart of albedo properties of lunar surface".
2. "The chart of colorimetric properties of lunar surface"
3. "The chart of polarimetric properties of lunar surface"
4. "The chart-scheme of the distribution of non-stationary events at lunar surface".
5. "The chart of thermal properties of lunar surface".
6. "The chart-scheme of the distribution of thermal anomalies at lunar surface".

"The chart of albedo properties of lunar surface" was mainly compiled from the material furnished by the "Chart of albedo of the Moon's visible hemisphere" compiled to 1:5 000 000 scale by the Kharkov State University's Astronomical Observatory. The basic problem in determining the map's thematic details proved to be the choice of the scale reflecting albedo variations at lunar surface. Put at the basis of the scale was today's global subdivision in terms of albedo of the Moon's entire surface into marine, high-albedo conti-

nental, low-albedo continental areas with the corresponding three clear-cut differences in albedo: ρ = 8.8; 12.2; 16.8 /2/. Analysis of the compilation material resulted in acceptance of a scale containing 10 steps, of which 4 reflect albedo variations at marine surfaces and 6 at continental surfaces. Albedo values in the red spectral region (λ = 0.62 mcm) are given as percentages from 7.6% to 23.2%. Albedo variations are conveyed in the yellow-brown gamut.

A preliminary analysis of thematic details in the compiled chart as a whole confirmed the presence of correlation between albedo and macrorelief; however, in some cases a direct relationship between albedo value and terrain relief is lacking. This is particularly characteristic of high albedo values corresponding to systems of bright rays. Accordingly, it appears useful to make use in the future of the albedo chart data in compiling the chart of bright rays.

"The chart of colorimetric properties of lunar surface" has been compiled on the basis of"The chart of the colour of the Moon's visible hemisphere" to 1:5 000 000 scale, likewise compiled by the Kharkov State University's Astronomical Observatory. The colorimetric scale contains 10 gradations The corlour index has been calculated from the formula $C = \frac{\rho\,(0.62\ \text{mcm})}{\rho\,(0.38\ \text{mcm})}$. The chart's colour scale is divided by the equidensit system into 16 intervals combined in 10 steps. The "blue" marine areas are identified by three steps, the "neutral" marine and continental areas coincide and are conveyed by one and the same colour shade, the "red"

marine and continental areas likewise coincide and are conveyed by four steps of the scale. It is worth pointing out that that the notions "red" and "blue" designate in the given case not a realistic reddening or blueing of the surface, but rather an increase or decrease of the reflective capacity in the respective spectral region /3/. Accordingly, classification into "blue", "red" and "neutral" surfaces, having a real physical sense, was used as a basis for the colour scale, for which three colours were employed - red, gray and blue.

From the analysis of the chart's thematic details it is possible to draw a conclusion about a weak relationship between the colour and the relief on a global scale (between seas and continents), whilst a relationship between colour and relief at small stretches does exist and depends, obviously, to a greater extent on the character of the surface microrelief and to a lesser extent, on the chemical composition of the rocks.

"The chart of polarimetric properties of lunar surface" has been compiled on the basis of the "Moon's polarimetric chart" to 1:20 000 000 scale, compiled by the Vakhushti Institute of Geography, Georgian Academy of Sciences, from the observation materials obtained at the Abastuman Astrophysical Laboratory. Variations in polarization are conveyed in a grayish-violet gamut. The scale contains 5 steps. Polarization values are expressed as percentages from 2.0% to 9.0%.

An analysis of the polarimetric chart's details reveals

the polarization pattern of lunar surface to be intimately interrelated with the physical nature of the body. Polarization is more prominent at marine areas and less prominent, at continental areas. Observable on the chart is a general gradual decrease of polarization values from central areas of the seas towards periphery and, thereupon, towards continent. However, identifiable against this background are individual stretches notable for regional specificities. An analysis of the relationship between amount of polarization and relief confirms that degree of polarization decreases with increasing height of the surface, as established by V.P.Dzhapiashvili /4/, only on a global scale. On regional and local scale this rule does not hold in every case.

"The chart-scheme showing distribution of non-stationary events at lunar surface" has been compiled by using the Catalogue made by B.Middlehurst et al. /6/ as well as V.P.Florensky and V.M.Chernov's Catalogue covering a period of 400-year observations /5/ as a basis. To be represented on the chart the non-stationary events have been classified according to external features into 4 groups: 1. Events related to variation of external appearance of the observed object (lack of shadow or central peak, dimming, haze, cloud), 2. Events related to variation of object brightness (bright spot, glow, flickering, lustre, red spot during eclipse), 3. Appearance and variation of dark spots, 4. Variation of the colour of the object. Moreover, it has been noted that the number of events observable in one region may differ from 1 to 170. Therefore, belonging to a group of

events and their quantitative appraisal for every point on the surface have been conveyed by conventional signs The most complicated and laborious aspect in compiling the chart happened to be identification of the areas, to which the observed events had to be related.

An analysis of the distribution of non-stationary events at lunar surface has revealed their corresponding areas to be mainly coinciding with the boundary zones of circular seas (Mare Imbrium, Mare Serenitatis, Mare Humorum, Mare Crisium), as well as with the boundaries between marine and continental areas and fresh craters endowed with systems of bright rays (Aristarchus, Tycho, Kepler). It is worth noting that events observable at some craters could be classed under the 2nd-3rd and even 4th group (Alphonsus crater

"The chart of thermal properties of lunar surface" was compiled on the basis of the "Infrared Atlas Charts of the Eclipsed Moon" drawn to 1:1 000 000 scale /7/. The temperature variations are conveyed in a pinky-orange gamut. The temperature scale contains 3 gradations: a) regions with ΔT 16°-24°K, b) regions with ΔT 24°- 28°K, c) regions with ΔT over 28°K

An analysis of data contained in "The chart of thermal properties of lunar surface" has confirmed a correlation existing between thermal properties and relief. Thermal anomalies mostly coincide with lunar seas, since corresponding precisely to these areas is ΔT in excess of 28°K. The maximum concentration of thermal anomalies takes place in the Ocean of Storms and in the Sea of Serenity. A minimal concentration of thermal anomalies corresponds with the continental area

lying between craters Tycho and Theophilus. Numerous thermal anomalies coincide with isolated craters.

"The chart-scheme showing distribution of thermal anomalies at lunar surface" was compiled on the basis of J.M.Saari and R.W.Shorthill's work /8,9/. Conventional signs are used on the chart-scheme to indicate weak thermal point anomalies, more intensive anomalies, as well as accumulations of thermal anomalies; a special sign is used to identify 30 most intense anomalies which have been mostly studied.

Thus, even a tentative comparison of characteristics represented at individual charts with the real relief clearly demonstrates the existence of diverse interrelationships between them and the practicability of their complex study on a standard cartographic basis. It is intended later to supplement the series with the charts of gravitation and magnetic anomalies, as well as with charts representing the results of radiolocation and some other measurements. The final stage in compiling the series will be compilation of complex charts demonstrating the presence of correlations between the aforementioned parameters

LITERATURE

/1./ Shingareva K.B., Burba G.A., Bobina N.N., Mironov V.I., A Standard Basis for Small-Scale Thematic Charts of the Moon, "Izv.Buzov", Geodesy and Aerial Photography Series, No.6, issue 1974.

/2./ Yevsyukov N.N. Statistical Distribution of Albedo Over Lunar Disc, "Astron.zh", 50, No.1, 1973.

/3./ Yevsyukov N.N. Certain Trends in Distribution of Colour Index at Lunar Surface, "Astron.zh.", 45, No.5, 1970.

/4./ Dzhapiashvili V.P. Polarimetric Chart of the Moon, "Astron.tsirkulyar", publ. by Bureau of Astr. Reports, USSR Academy of Sciences, No.788, 1973.

/5./ Florensky V.P., Chernov V.M. Observation of Non-Stationary Events at the Moon and of Earth's Shadow Near It Against the Background of the Sky, "Astron. vestn.", USSR Academy of Sciences, "Nauka" Press, Moscow, 1973.

/6./ Middlehurst B., Burley J., Moore P., Welther B. Cronological Catalogue of Reported Lunar Events, NSA, Wash. 1968.

/7./ Shorthill R.W. Infrared Atlas Charts of the Eclipsed Moon, "The Moon", 7, 1973.

/8./ Saari J.M., Shorthill R.W. Hot Spots on the Moon, "Sky and Tel.", 31, 6, 1966.

/9./ Saari J.M., Shorthill R.W. Thermal Anomalies on the Totally Eclipsed Moon of December 19, 1964, "Nature", 205, 4975, 1965.

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