INDICATRIX MEASUREMENTS OF LUNAR SAMPLES FROM LANDING SITES OF LUNA 24, LUNA 16, and LUNA 20

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Optical parameters investigation of lunar samples is important for extending of knowledge about returned samples to the large region of the Lunar surface. Such investigations are also necessary for comparative study of samples from different landing sites. We assume that optical characteristics including the color-index change with phase-angle are steady against bringback operation.

The scattering indicatrix measurements are carried out with the constructed photometer at two wavelength 0,65 μm and 0,43 μm. The beam divergence angle of incidence and reflectance beam was 0,8 at minimum phase angle 1°. The measurements were made at fixed incidence angle of 15° and at changed reflectance angle (between 0° and 60° from normal to the surface for both sides). The thickness of samples layer was about 1-2 mm and the diameter of those was 8 mm. The measurements were made for phase angle interval 0-60° per step equal 0°75. General description of the samples can be found in Table 1.

Table 1

Samples	Depth(cm)	Fraction size(μm)
24092.4-1	92-95	<74
24118.4-1	118-121	<74
24143.4-1	143-146	<74
24143.4-3	-"-	94-200
24184.4-1	184-187	<74
24184.4-3	-"-	94-200
2002-1	5-10	<83
2002-4	-"-	200-450
1603-1	0-8	<83

The sets of curves in figs.1-3 show the change sample color-index versus phase angle. We assumed that color-index C ($R_{0,65}/R_{0,45}$) was equal to 1 at 6° phase angle. Every curve point was the mean of three measurements. The curves show increasment of color-index on 3-7% for the 0-60° phase angle interval. This result is in agreement with cord telescopic observation, results (1).

Many of the curves show anomalous color-index increase versus phase angle decrease. At first O'Leary et al (2) and Akimov et al (3) paid attention to this peculiarity. Fig. 1 presents the color-index dependence of fines versus phase angle for three parts of core tube Luna 24. Each of the curves have approximately the same color-index minimum value and its position is near 6°, and these parameters are independent on core tube depth. Fig.1 shows also curves irregularity on the long indicatrix branch for phase-angle interval 20-25°. The curves asimmetry relative to 0° phase-angle for these and other samples can be explained by the weak color dependence of lunar samples on incidence and reflectance angle.

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The fine measurement results of Luna 24, Luna 16 and Luna 20 are presented in fig.2. The comparison of samples from different landing sites can be derived from these curves. Luna 16 fine has the more pronounced phase peculiarity of color-index. Luna 20 regolith and terrestrial samples (composition of pulverised olivine, pyroxene and ilmenite)don't have such peculiarity and Luna 24 fines have intermediate characteristics. Color-index measurement results for coarse-grained samples are presented in fig.3.

Now there is no satisfactory quantitative model describing peculiar dependence of color-index versus phase angle. It is suggested that the Moon reddening can be explained by scattering of high orders. Some authors pointed out that polarization characteristics could influence on color-index curve (1,4). We suppose that color-index anomal behavior at 0° phase angle is explained by backscattering by means of transparent in long wave length spectral region particles (for instance, silicate fines). There is possibility to explain the descripted effect by "glory" and "rainbow", if such particles sizes are larger than incident light wavelength and their forms are like sphere or cylinder. Grezky (5) has used "glory" and "rainbow" rise mechanism to account phase brightness curves of Saturn rings.The presence of one or more percent of such transparent particles on lunar fine surface is sufficient to influence upon phase dependence of brightness. The results in fig.3 are in agreement with this consideration and show that the anomal increase of color-index occure more markedly with increase sample maturity. The concentration of halftransparent agglutinate is increasing in that maturity coarse-grained samples (6).

The orange globules from Apollo 17 landing site have to contribute the peculiar effect in reflected light. The mean size of these particles is 40 μm. It is supposed that there is great concentration of those in volcanic active region "The Wood spot" (7). For investigation of five color-index effects on the Moon such regions are of great interest. However, it is necessary to increase accuracy of terrestrial measurements for such investigations.

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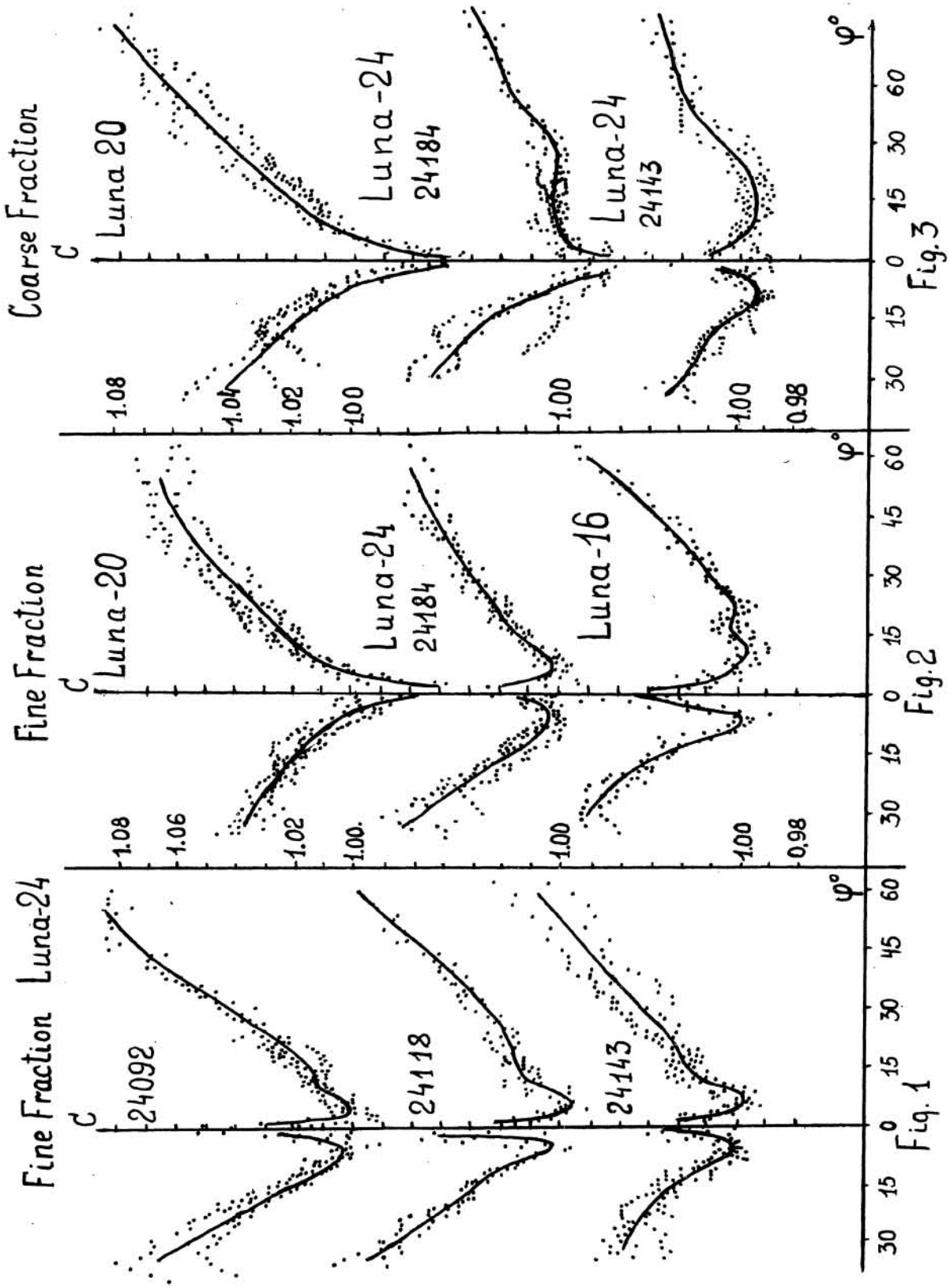

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