REMOTE SENSING ASSESSMENT OF THE LUNAR SOIL MATURATION; V.V.Shevchenko, Sternberg State Astronomical Institute, Moscow University, Moscow 119899, Russia

The amount of fused glassy particles in the lunar soils is a direct index of the amount of micrometeorite reworking of surface layer and hence of soil maturity. The surface exposure (maturity) index as rate of agglutinates and glassy fragments in lunar soils was proposed by Florensky et al. [1]. The values of the maturity index $\mathbf{I_m}$ range between 0 (start of regolith forming) and 1.0 (saturation of regolith by reworked particles) units. Other quantitative index of surface maturity was proposed by Morris [2]. This maturity index $\mathbf{I_f}$ is the ratio of the value of the intensity in arbitrary units of the FMR resonance to the value of the FeO concentration. Comparison of the lunar samples data from [3] and [4] let us to construct the following equation showed correlation between $\mathbf{I_m}$ and $\mathbf{I_f}$ values (r = 0.971): $\mathbf{I_m}$ = - 0.0139 + 0.0121$\mathbf{I_f}$. The mean values of maturity indices for lunar samples from six Apollo landing sites were used (Fig. 1).

The increasing rate of fused glassy fragments in regolith leads to changing average value of refraction index of the surface layer substance. Therefore polarimetric and spectropolarimetric properties of the regolith must be varied by the reworking soil in course of time. On the base of known laboratory results and telescopic data it was found that spectropolarization ratio $\mathbf{r = P_{max}(B)/P_{max}(R)}$ for blue and red spectral region could be used as remote sensing parameter of lunar soil maturity. It correlates with value of maturity index derived from morphological or ferromagnetic methods. Using lunar samples data for nine Apollo and Luna landing sites and spectropolarimetric telescopic data for these sites it was obtained correlation of the spectropolarimetric ratio $\mathbf{P_{max}(0.42\mu m)/P_{max}(0.64\mu m)}$ from [5] with morphological index of the lunar soil maturity from [6]. This correlation is shown in Fig. 2. The least-squares method gives the following relationship for linear regression (r = - 0.932): $\mathbf{I_m}$ = 2.401 - 1.111 **r**. Relationship based on the spectropolarimetric ratio **(0.42μm/0.70μm)** has analogous form but the correlation is not so strong in this case (r = -0.883).

As it was expected, a strong correlation between maturity index $\mathbf{I_m}$ and exposure age **T** was found. Using 15 lunar samples data the dependence of the maturity index (values of $\mathbf{I_m}$ for 15 different lunar samples was taken out from [3, 7]) from exposure age (values of **T** for the same samples was taken out from [7- 11]) was obtained. The least-squares method gives the following equation: $\mathbf{I_m}$ = 0.226 + 0.243 ln **T**, where **T** is in units of million years. The data are plotted in Fig. 3 (r = 0.938).

Table 1 lists the derived values of maturity index and exposure age for a number of lunar morphological features. Column of **D** lists the values of telescope diaphragm projection on the lunar surface (km) [5].

Table 1. Soil maturity and exposure age of lunar formation surfaces.

Formation name	I_m	T	D	Formation name	I_m	T	D
Reiner-gamma	0.273	7.8	6	Mare Serenitatis	0.789	65.2	14
Mare Fecunditatis	0.440	15.5	14	Reiner	0.859	84.4	6
Plinus	0.456	16.6	6	Gassendi	0.880	94.7	28
Proclus	0.524	21.9	6	Clavius	0.901	103.3	28
Aristarchus	0.549	24.3	6	Lansberg	0.914	109.2	6
Flamsteed	0.676	40.9	3	Arzachel	0.938	120.3	14
Mare Imbrium	0.760	57.8	14	Grimaldi	1.042	184.5	14

Table 1 lists both mare and highland formation data for different morphological type features. The most immature soil was found in area of a swirl like Reiner-gamma formation. According to classification of Morris [4] a such type of immature soil material includes not more than only 28% of agglutinates. The immature regolith ($\mathbf{I_m}$ < 0.35) is observed on the surface of mare bright rays and inside youngest bright craters. The submature soils (0.35 < $\mathbf{I_m}$ < 0.70) are associated with fresh dark mare material. The mature regolith ($\mathbf{I_m}$ > 0.70) is located within old mare and highland craters. When residence time of soil in the upper layer of regolith is equal 150 - 160 million years it is occurred the saturating soil by agglutinates ($\mathbf{I_m}$ is near 1.0).

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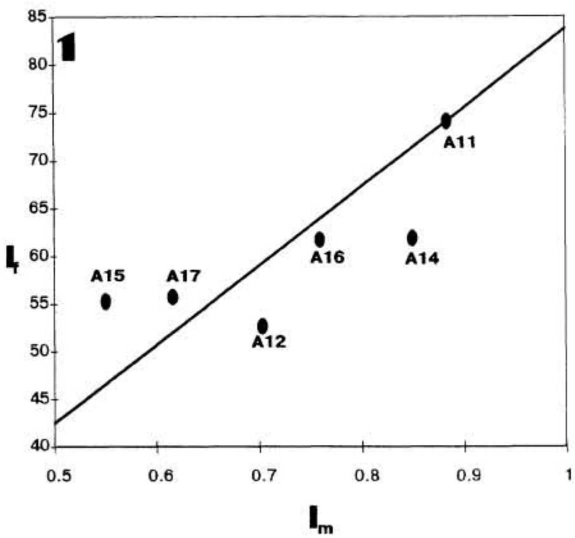

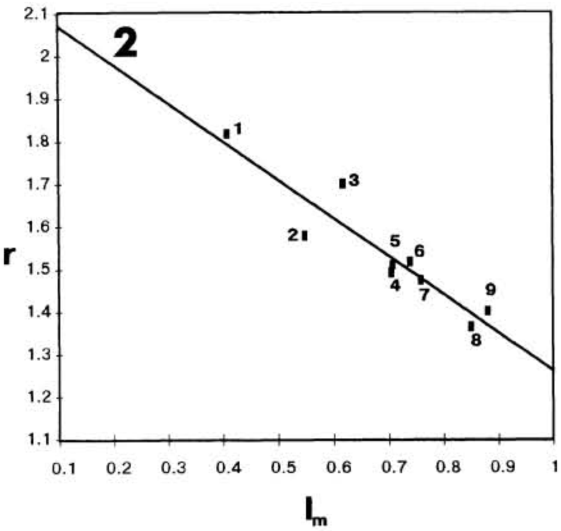

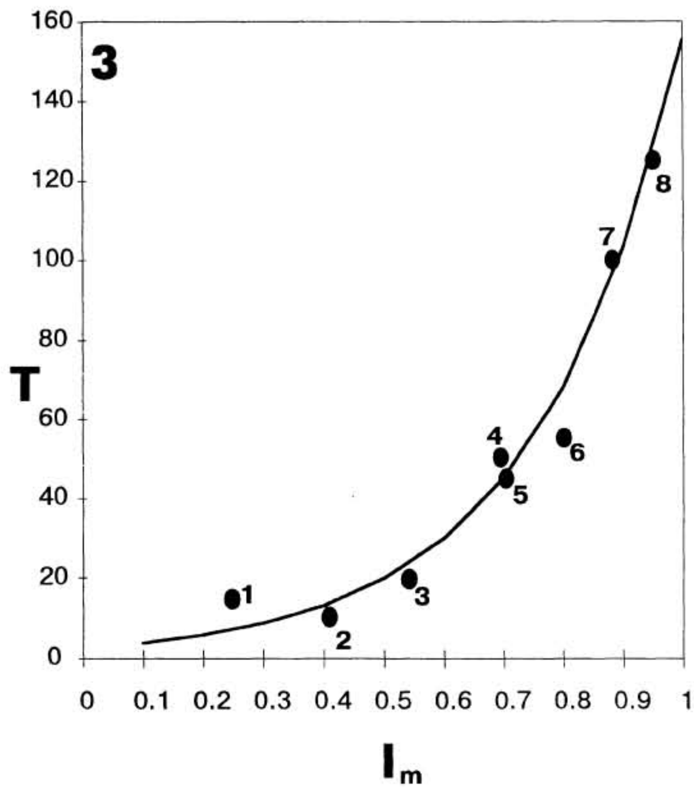

Figure 1. The correlation between morphological index of the lunar soil maturity $\mathbf{I_m}$ and magnetometric maturity index $\mathbf{I_f}$. The points are average data for lunar samples from landing sites of Apollo-11, -14, -15, -16, 17, respectively. Values of $\mathbf{I_m}$ are taken out from [3], values of $\mathbf{I_f}$ are taken out from [4].

Figure 2. The correlation between morphological index of the lunar soil maturity $\mathbf{I_m}$ and spectropolarization ratio $\mathbf{r = P_{max}(0.42\mu m/0.64\mu m)}$ The points are data for areas of the following spacecraft landing sites: 1 - Luna-20, 2 - Apollo-15, 3 - Apollo-17, 4 - Apollo-12, 5 - Luna-24, 6 - Luna-16, 7 - Apollo-16, 8 - Apollo-14, 9 - Apollo-11.

Figure 3. The correlation between maturity index $\mathbf{I_m}$ [3, 7] and exposure age **T** (10^6 yr) [7-11]. The points are lunar sample data: 1-12037(Apollo-12), 2 - 2001-2004(Luna-20), 3 - 74220, 74240, 74260 (Apollo-17), 4 - 67701(Apollo-16), 5 - 14141(Apollo-14), 6 - 67601(Apollo-16), 7 - 10010-10011(Apollo-11), 8 - 60009-60010(Apollo-16).

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