CHEMICAL MODIFICATION IN THE LUNAR OLIVINE MICROCRYSTALS UNDER THE SOLAR COSMIC RAY.

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Introduction. Previous investigations [1] of the lunar regolith silicate crystals demonstrate the possibility of measuring the radiation effects from the solar cosmic ray (SCR) nuclei of the iron VH-group in the individual silicate microcrystals. Due to charge, mass and energy of the cosmic ray nuclei in the exposed silicates different radiation effects can be influenced [2]. One of these is the chemical and phase composition modification of silicates. Modelling of these processes with the help of the accelerated low-energy ions H, D, He and Ar [3,4] indicate that chemical composition of the interplanetary matter could be essentially changed. For these reasons experimental investigations of the volume distribution inside an individual lunar regolith silicate microcrystals subjected to different exposure SCR protons and α - particles dose, are important. This paper reports: (1) The new results on investigation of the radiation parameters in the individual silicate micrograins of the lunar regolith matter, determined by using fossil track method [1] and (2) Preliminary results of the chemical modification observed in the some searched crystals.

Samples and method. Olivine crystals (about 80 grains) from the Luna-24 soil sample No 24184 of 0.127÷0.200 mm size fraction were taken for the investigation. The crystals were mounted in epoxy-resin tablet, polished and, on the freshly revealed internal cut-off surfaces the chemical composition profiles were measured with the help of Electron Microprobe technique. Then, on the same crystal surfaces chemically etched VH-nuclei tracks were observed [1]. Estimation of the total proton and α-particle exposure dose was done on the base of experimentally established VH-nuclei track production rate $(d\rho/dt)_X$ *vs* depth (X) of scoop near lunar regolith surface. For the shielding surface layer from 2×10^{-3} cm up to 10^{-1} cm $(d\rho/dt)_X = 1.2\times X^{-0.75}$ track/cm^2 yr. [5]. Thus, the olivine grains that do not demonstrate a well-defined track-density gradient and have uniform track distribution of $\rho = 10^6 \div 10^7$ track/cm^2 have been exposed near the submillimeter regolith depth for the time T = 1÷10 m.yr. Corresponding SCR proton and α-particle integral fluxes estimated in that way were obtained. Calculation of the implant range profile of protons and α - particles [6] indicate that at E ≥ 10 MeV/ion induced degree of crystal lattice damage varied along the olivine grain depth within the limits of 5 ÷ 50 %.

Results and Discussion. Track densities and accounted protons and α - particles dose values detected in the eight individual olivine grains, are presented in Table. Practically all observed tracks are due to VH nuclei (iron group 23≤Z≤28) of the solar cosmic rays. Note that track density of the spontaneous and induced fission of Th and U is negligible small (≤0.1%) and is not taken into account.

Table. Characteristics of the solar cosmic ray irradiation in the searched olivine crystals extracted from the Luna-24 soil column.

n_o	Sample	Track (*) Density, ρ cm^{-2}	Exposure (**) Age, m.y.	Dose, cm^{-2} ($\times10^{17}$) (***)	
				Protons	α - particles,
1	I –1	$(1.5 \pm 0.1)\times10^7$	2.5	7.9	0.55
2	I – 2	$(3.2 \pm 0.4)\times10^5$	0.06	0.2	0.019
3	I – 5	$(5.0 \pm 1.0)\times10^4$	0.008	0.025	0.00175
4	I – 7	$(1.5 \pm 0.1)\times10^7$	2.5	7.9	0.55
5	I – 8	$(2.4 \pm 0.3)\times10^5$	0.04	0.13	0.09
6	II – 2	$(1.2 \pm 0.1)\times10^6$	0.5	1.6	0.11
7	II – 8	$(1.3 \pm 0.1)\times10^7$	2.2	6.9	0.48
8	III - 8	$(1.4 \pm 0.1)\times10^6$	0.23	0.7	0.049

(*) Track density (ρ) values for VH-nuclei of the SCR, E_{VH}=(10÷100) MeV/nuclon.

(**) Estimation by relation $\rho_{0.1\ cm}=6.7\times10^6$ track/cm^2·m.y. (see text).

(***) Accounted on the integral flux of the SCR protons: $I_{P,E\geq1MeV} = 10^4$ protons/cm^2·s. Integral flux of the SCR α-particles $I_{\alpha,E\geq1MeV/nucl} = 0.07\times I_{P,E\geq1MeV}$ particles/cm^2·s

Some examples of the visible chemical changes, determined along profiles in the analysed olivine crystals are shown in Figure. The degree to which radiation-induced element redistribution can be expected inside of the olivine crystals on the ~ 100 μm scale, however, remains to be established in the future modelling experiments.

Conclusions. (1) On the base of the first-step results obtained we can state qualitatively, that in some lunar regolith olivine grains we can observe changes in Mg, Fe, Ca and Si concentration weakly-sloping from edge to edge of single crystals. This can be due to comparatively high (up to ~10^{18} protons/cm^2) dose values of the SCR irradiation. (2) Track *vs* chemical composition investigation in the eight olivine samples from the Luna-24 column soil gives the preliminary results about the possibility of the SCR influence on the chemical modification in the single grains. (3) Estimated age of the near surface (up to 0.1 cm depth) solar cosmic ray irradiation and the accountable proton and α-particle energy spectrum are the main quantitative parameters for the accurate calculation of the total proton and α-particle exposure dose. (4) Small portion of the relatively high-irradiated olivine crystal grains (ρ ≥ 10^7 track/cm^2) demonstrate the correspondingly low degree of cosmic ray influence upon the Luna-24 searched sample.

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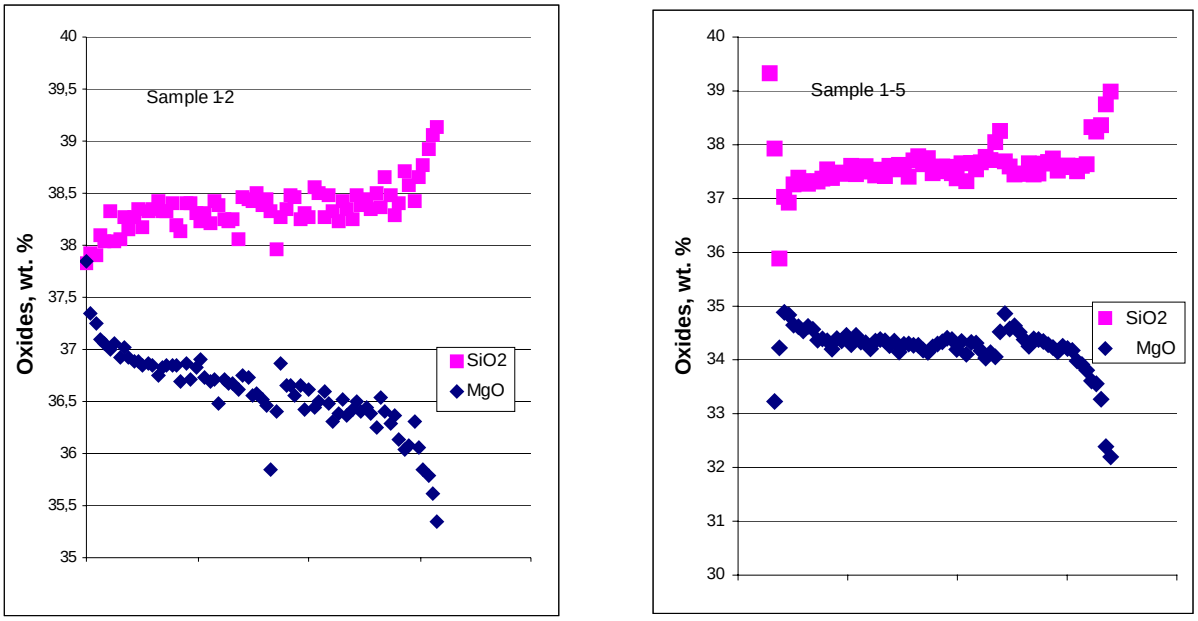

Fig. Concentration profiles of MgO and SiO_2 across single olivine grains from the Luna-24 samples