ON EXPERIMENTAL MODELING OF RADIATION INFLUENCE ON CRYSTAL MATTER IN THE LUNAR SURFACE

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Introduction

The lunar regolith matter is exposed to influence of a wide spectrum of cosmic ray particles. Depending on their charge, atomic mass and energy in silicate crystals are possible of different radiation effects [1]. One of them is the change of chemical and phase structures in silicates, irradiated on the regolith surface by the most intensive flow of a solar wind (SW) and solar cosmic ray (SCR).

Modelling of processes of silicate modification under influence of the low-energy H, D, He and Ar ions [2, 3] has shown, that the chemical structure of interplanetary matter can be essentially changed as a result of its irradiation by the nuclear cosmic ra a big difference y component. In this connection, one of the cosmo-chemical tasks is the research of processes of ion modification of elemental and structural composition of natural objects, in particular, of lunar regolith silicates.

The purpose of the present research is the development of a technique of search, identification and selection of individual microcrystals of silicate minerals from lunar regolith matter with the certain radiation and radiation-thermal characteristics. The selected thus crystals intend for study of processes of structural and chemical modification, initiated in them at an irradiation by SW and SCR particles during a presence on a surface of the Moon.

In work the most typical cases of an irradiation of microcrystals on a lunar regolith surface are presented. For individual silicate crystals on the basis of the measured parameters of VH-tracks, group Fe ($23<Z<28$) SCR the quantitative estimation of doze value of SW ions of different elements and various energy can be carried out.

Effects of radiation influence on a surface of the Moon

The matter on a lunar surface in absence of a shielding layer is exposed to an irradiation by the most intensive flow of SW and SCR nuclei. Because a big difference of SW and SCR nuclei energy, practically in each of crystals ever irradiated on a lunar surface, there are traces of a different sort of radiation micro-lattice disturbance. Most typical for the strongly irradiated microcrystals are amorphous coatings formed on a surface of crystals as a result of bombardment by SW ions, and also tracks of SCR VH-group nuclei.

Amorphous coatings on a surface of crystals. Amorphism of the top layer of crystals occurs in result of implantation of low – energy SW ions ($E_{ION} \sim 1$ keV × nucl^{-1}). The thickness of amorphous layers should correspond to length of path of ions H and He, which consist about 97 % of all SW radiation. However, as have shown numerous supervision of lunar microcrystals from a column "Luna-16", this thickness changes from ~ 10 nm up to ~ 100 nm. It is possible to specify two basic reasons resulting in essential distinction of a layer thickness: 1) Geometry of an irradiation of a crystal on a regolith surface, when the maximal thickness of amorphous layer will correspond to a case normally focused SW ions to an irradiated surface; 2) Possible moving off a part of amorphous matter as a result of erosion processes. In such conclusion, in particular, results detection in some strongly irradiated lunar crystals, gas bubbles, located in thin (≤ 0.1 μm) near-surface layer of these crystals and occurred as a result of heating of irradiated by SW ions crystals [4]. Essential that at large bubble-density the part from them is blocked with each other, bubbles are opened, and it results in effective removal of matter from a crystal surface. Besides, the erosion occurs as a result of bombardment by micrometeorites, and also at nuclear collisions.

Thus, proceeding only from the fact of presence or absence on a surface of crystals of an amorphous layer, it is impossible to make an unequivocal conclusion as about a probable irradiation of these crystals by SW ions, and about a total doze of an ion irradiation.

Tracks of VH-group SCR nuclei. The depth of penetration of VH-group nuclei forming tracks in silicates, depending on energy makes from ~ 0.1 μm up to ~ 15 μm for E_{Fe} = (0.1 - 10) $MeV/nucleon^{-1}$. The nuclei with such energy are included into SCR composition and are the basic source of tracks observable in silicates, ever exposed on a lunar surface.

By way of a considered problem it is necessary to specify the following characteristics of track researches: (1). Density of tracks from SCR VH-nuclei in the low-energy field (≤ 1 MeV× $nucleon^{-1}$) amount to (10^{10} – 10^{11}) track × cm^{-2}. The crystals of the micron sizes with such track-density are studied with the help high-voltage electron microscope [5]. However conditions of supervision in this case do not give opportunities for the further selection and research of micro-crystals with the maximal implanted doze of SW ions; (2). The crystals by the size ≥10 μm having as very high (~10^{10} track × cm^{-2}) track-density are studied with the help of electronic scanning microscope. However, it is necessary in this case to carry out preliminary "soft" chemical etching of tracks.

Conclusion

Considered above results in necessity of application of the following technique of detection and selection of individual crystals of a lunar silicate micro-crystals intended for study in them of ion modification processes under influence of SW ions and rather of low-energy SCR nuclei: (1) For research from a lunar regolith matter the silicate crystals by the size not less ~ (50 - 100) μm are selected; (2) Crystals, mounted in epoxy-resin tablets, are grinded, polished and etched in "soft" conditions with the purpose of revealing the most strongly irradiated samples; (3) After preliminary viewing and the identification of crystals with density of tracks are not lower ~ 10^8 track × cm^{-2} the selected crystals are mounted secondly on a new tablets, with help of which the detail measurement of track parameters are measured on electronic scanning microscope. The main criterion of an irradiation of the given crystal on a lunar surface is presence of a track-density gradient. The character of change of track-density in near-surface (~20 μm) layer of a crystal is, in particular, indicator of an erosion degree. For crystals with total volume high track-density without of a gradient, the irradiation for a long time on some regolith depth is possible. In this case radiation influence from SW ions is under doubt.

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