COSMOGENIC ^{22}Na AND ^{26}Al IN LUNA 24 DRILL CORE SOIL SAMPLES

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The special interest of scientists to the samples brought to earth by the Soviet Luna 24 automatic station has been caused first of all because of the peculiar place of Luna 24 landing site (1) 18 km east of the centre of Farenheit Crater, that enabled to expect a complicated history of formation of lunar regolith, and even to hope to find traces of exotic ejections from the lunar interior. Tracks of heavy nuclides and data on stable isotopes have enabled to fix the processes of the lunar surface evolution for a long time scale, however, they do not give sufficient information about processes lasting during the past $\leq$ 5 Myr. The best indicators of this period are radioactive cosmogenic nuclides with various half-lives enabling to compare a present state of the lunar surface with an average during the last million years. A rare gift of Nature is a pair of cosmogenic nuclides, ^{22}Na-^{26}Al, with half-lives of 2.6 yr and 0.74 Myr, respectively. Thanks to the similar excitations functions of their production from nuclides forming the lunar material, the ratio of these cosmogenic nuclides practically does not depend on the irradiation geometry of samples and their shielding conditions. This enables to compare conditions for irradiation of lunar surface and processes of their evolution during the last ~4 years as well as during the last million years. Radioactivity of ^{22}Na and ^{26}Al in samples 24080-24102 and 24105-24114 of the Luna 24 drill column has been reported (2). As the top part of the core, length of 47 cm, was not filled with the lunar material, there is some uncertainty in the estimation of zero level of the lunar soil brought to earth. We are using as the zero level the mark 64 cm, in agreement with a measurement of the depth profile distribution of ^{21}Ne (3). The excess of the measured radioactivity (2) above the calculated one for both radionuclides (see Fig. 1) unambiguously confirm that the lunar surface was mixed at least for depths 20-30 cm from the zero level in the last $\ll$4 years, i.e. most probably in the moment of drilling. In this work we present results of measurements as well as calculations of radioactivity of ^{22}Na and ^{26}Al depth profiles in the samples 24118.4-4, 24143.4-4 and 24184.4-4. The radioactivity measurements were performed nondestructively using a high sensitive beta-gamma-gamma coincidence spectrometer in the low background laboratory of the Comenius University in Bratislava (4,5). The obtained results are presented in Table 1. The calculations were done using the earlier suggested and developed analytical method (6,7)

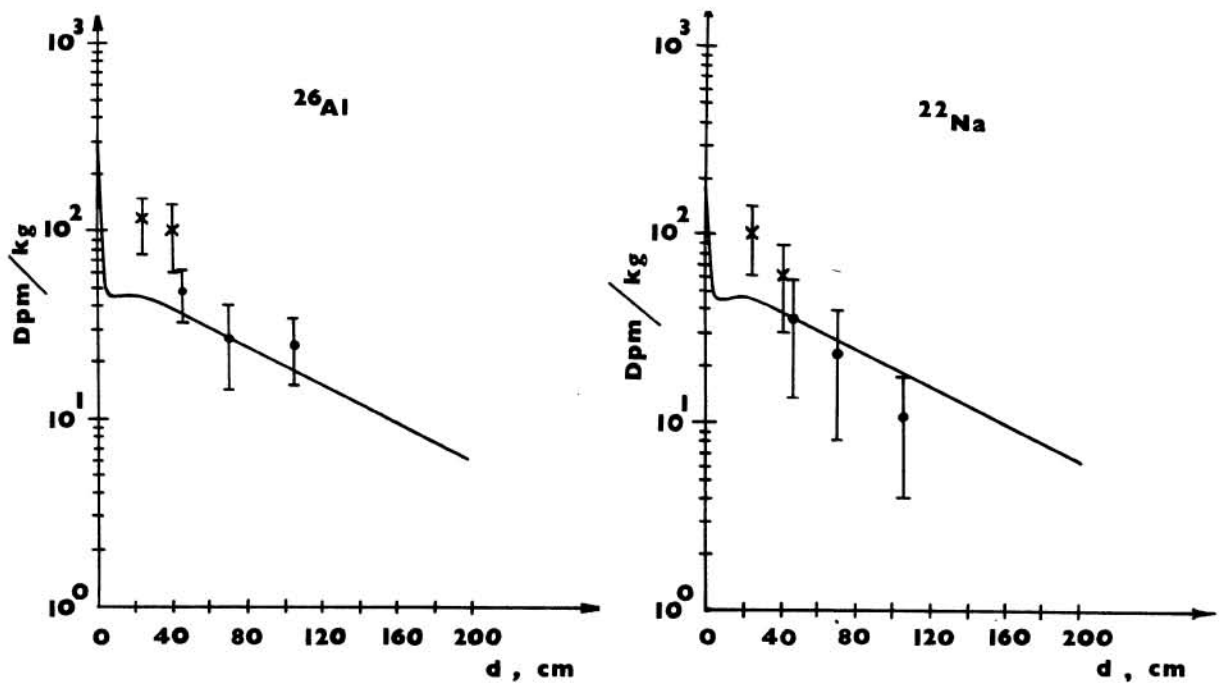

Fig. 1. The depth profiles of ^{22}Na and ^{26}Al in the Luna 24 drill core (experimental points and theoretical curves-this work, (+) - data from the work (2), d - depth from the lunar surface, representing at d=0 the mark 64 cm from the top of the core).

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Table 1.

Radioactivity of ^{22}Na and ^{26}Al in the Luna 24 drill column

Sample	Depth from the lunar surface	Radioactivity dpm.kg^{-1} ^{22}Na	^{26}Al	$^{26}Al/^{22}Na$
24118,4-4	46	37 ± 23	49 ± 16	1.32 ± 0.84
24143,4-4	70	24 ± 16	27 ± 13	1.13 ± 0.91
24184,4-4	105	11 ± 7	25 ± 10	2.27 ± 2.16

In the calculation of ^{22}Na radioactivity an average intensity of galactic cosmic rays (GCR) in the last ~4 years (~1.5 $T_{1/2}$), before drilling the core in August 1976, of 0.31 particles .cm^{-2}.s^{-1}.sr^{-1} (R > 0.5 GV) was used. For calculation of ^{26}Al radioactivity a contemporary average value of intensity of GCR (8) of 0.24 particles .cm^{-2}.s^{-1}.sr^{-1} (R > 0.5 GV) was used. As an average intensity of solar protons a value of 2.46 protons .cm^{-2}.s^{-1}.sr^{-1} (E > 20MeV) was used, well reproducing the depth profiles of both radionuclides in lunar sample 10017, brought to earth by Apollo 11 mission (9). The calculated depth profiles of ^{22}Na and ^{26}Al in lunar regolith together with experimental results from Table 1 and results obtained in (2) are shown in Fig. 1. It can be seen, that both the theoretical and experimental values of radioactivities of both nuclides are the same within the errors. This is because of the compensation of lower cross-sections for ^{22}Na production by a higher intensity of GCR in the period of building up its observed radioactivity, in comparison with an average contemporary intensity used in calculation of ^{26}Al. Further, as the most important result, it is necessary to stress a qualitative agreement between the theoretical profiles of the depth distribution of both radionuclides with the experimental ones, below ~40 cm from the lunar surface. This means, at first, that at least for the depths below ~40 cm from the surface, the lunar material was not mixed and, at second, that at least in the last million years the surface layer of the regolith in the landing site of Luna 24 has been irradiated in situ unchangeably. Results shown in Fig. 2, where the ratio $^{26}Al/^{22}Na$ is plotted with depth, give evidence about the constancy of the average intensity of GCR during the last million years. It is necessary to note that a similar result has been obtained from the analysis of ^{26}Al radioactivity in lunar samples brought to earth by Soviet automatic stations Luna 16 and Luna 20 (10).

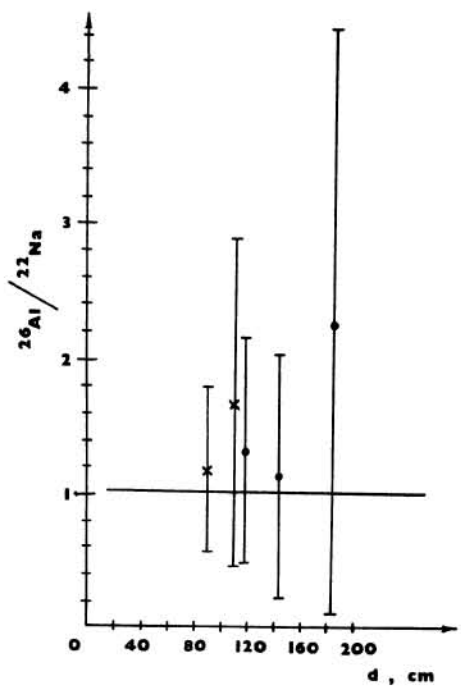

Fig. 2. The depth profiles of the ratio $^{26}Al/^{22}Na$ in the Luna 24 drill core (experimental points and theoretical line--this work, (+)-data from the work (2), d - depth from the top of the core).

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