THE IDENTIFICATION OF TRACKS DUE TO Th-U COSMIC-RAY NUCLEI IN OLIVINES FROM PALLASITES; V.P. Perelygin, S.C. Stetsenko; Joint Institute for Nuclear Research, Dubna I4I980, USSR

The experimental study of fossil tracks due to the heaviest Galactic cosmic ray nuclei in meteoritic olivine crystals has been perfomed at the Laboratory of Nuclear Reactions, JINR, during I980-I987 in order to identify anomalously long tracks from the $Z \geqslant 110$ nuclei (1,2). The crystals from the meteorites-pallasites Marjalahti and Eagle Station were used. Before etching, these crystals were annealed at 430°C during 32 h. The semiempirical dependence of the volume etchable track length on atomic number Z was based on only one experimental point for $^{I32}Xe_{54}$ - L=26.5±2.5 µm. In the first experiment (1) in the track length spectra obtained under these annealing conditions (fig.1a) one can see the track groups at I20-I40 µm.

These groups were attributed (1) respectively, to Pt-Pb and Th-U cosmic ray nuclei; in addition, one anomalously long track, L=365 µm, has been found. In a further study (2), the number of tracks with L ~210 µm exceeds 1100, and the number of tracks with L 350 µm reaches 10 (fig.1b). For identifying of the tracks with L ~2I0 µm and to clarify the origin of tracks with L ≈ 350 µm it was necessary to calibrate mateoritic olivine crystals with accelerated Au, Pb and U nuclei. The first experiment of this kind was carried out at the Bevalac accelerator (LBL, Berkeley) in November I987 (3). The energy of ^{238}U nuclei was 30 and 70 MeV/n, the angle of incidence was 25° and, for some crystals, 10° to the polished olivine surface. The annealing, etching and tracks measuring procedure were the same, as in previous experiments (1,2). The results of track measurements in 83 crystals from the Marjalahti meteorite are shown in fig.1c, the maximum of the ^{238}U track length spectrum corresponds to 230±25 µm (3).

Both the shape and half-widht of this spectrum aggrees with those for "fossil" track group 2I0± 20 µm in length (figs.1a,1b). For 32 olivine crystaks from Eagle Station pallasite we observe rather good incidence of the track lenght spectrum of ^{238}U and the group of "fossil" tracks (~22C µm and ~2I0 µm).

The longest track in the ^{238}U spectrum has a length of up to 330-370 µm (fig.1c). But the thorougful analysis of the crystals containing the longest ^{238}U tracks shows that these tracks oriented very closely to the (010) main crystal planes of the olivines. This does not take place for at least 50% of ~350 µm fossil tracks. Thus, the problem of the origin of the longest fossil tracks still remains unsolved and meeds further investigations.

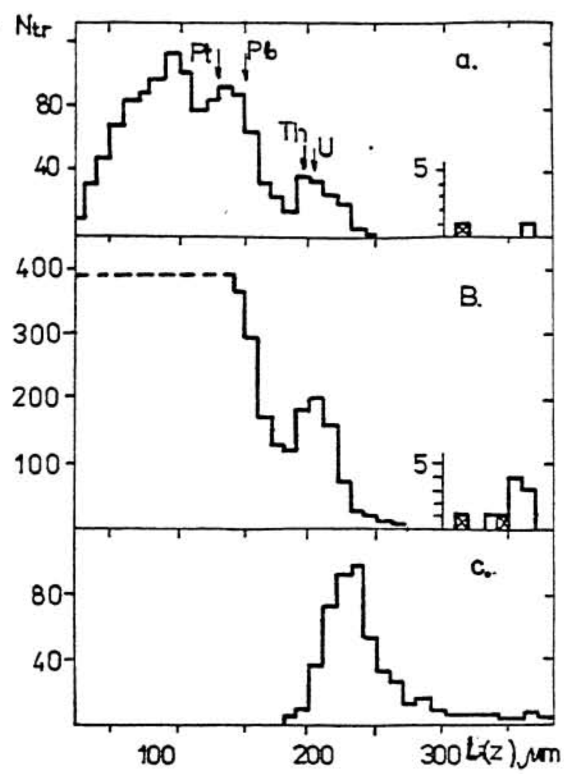

Fig. 1

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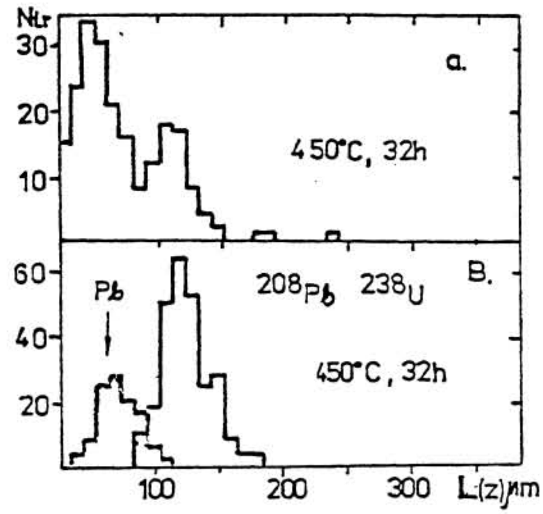

For the purpose of a more detailed study of the thermal stability of ^{238}U and ^{208}Pb tracks (crystals were irradiated at UNILAC, GSI, Darmstadt) in olivines were carried out experiments on annealing such crystals during 32 h at temperatures of 450°C. The resultes of this annealing study are presented in fig. 2. For annealing at temperatures 450°C the mean ^{238}U track length is 120±20 μm and 70± 15 μm for ^{208}Pb track respectively. One can compare these track lenght spectra with fossil track length spectra (fig. 2b, L_{tr} = 115 μm) in olivine crystals, annealed in the same conditions.

Turning to the analysis of the results obtained, one can conlude that, first, the fossil tracks with a mean length 210 μm (figs. 1a,b) have been formed by the cosmic-ray nuclei group of Th–U, formed in r-process events in our Galaxy during last 200 MY of its history.

Second, the calibrations of olivine crystals with ^{238}U nuclei provide a quantitative basis of a new method of investigating galactic cosmic-ray nuclei (Z ≥50) by studying tracks in extraterrestrial crystals. This method surpass in sensitivity all other known methods.

1. Perelygin V.P., Stetsenko S.G. Pisma ZhETF 32 (I980) 622.
2. Perelygin V.P., Stetsenko S.G., Flerov G.N. Rapid Comm. JINR № 7-85, p.5, Dubna I985.
3. Perelygin V.P., Stetsenko S.G., Crawford H.J., Symons T.J.M. JINR preprint E7-89-88, Dubna I989.