NEW METHOD OF THE SUPERHEAVY COSMIC RAY NUCLEI TRACK PARAMETERS DETERMINATION IN THE PALLASITE OLIVINES

Kashkarov L.L. (GEOKHI RAS), **Polukhina N.G.** (LPI RAS), **Starkov N.I.** (LPHI RAS), **Kalinina G.V.** (GEOKHI RAS), **Ivliev A.I.** (GEOKHI RAS), **Alexandrov A.B.** (LPI RAS), **Goncharova L.A.** (LPI RAS), **Apacheva I.Yu.** (LPI RAS)

cosmo@geokhi.ru, *ugeochem@geochem.home.chg.ru*; *poluhina@sci.lebedev.ru*

Key world: tracks of heavy and super-heavy cosmic ray nuclei, olivine crystals from meteorites, automated scanning of solid-state track detectors.

Introduction. In continuation with previous studies [1] the “Olimpiya” project [2] is based on the solid-state track detector technique, where radiation damages produced by penetrating galactic cosmic ray (GCR) nuclei in the olivine crystals from meteorites. In the search for ancient tracks use is made of the ability of silicate crystals to register and preserve tracks of nuclei with Z ≥ 23 over a long period of time. The cosmic ray exposure age of pallasite meteorites are estimated to be ~ $(5\div20)\times10^7$ years, during of which 10^2-10^3 tracks of nuclei with Z ≥ 90 could be produced in 1 cm^3 of crystals sited at ≤ 5 cm beneath the pre-atmospheric meteorite surface. Therefore, by measuring the parameters both for the fossils and artificially induced in calibration experiments tracks one can identify charge of GCR nuclei. For the sample scanning with the goal of searching and processing tracks of heavy and superheavy GCR nuclei in the pallasite olivine crystals, it is suggested to use modern high-performance completely automated measuring device system PAVICOM [3].

Methodology of track parameters determination. The PAVICOM program of the track search and processing provides scanning over three coordinates, gives pointing for the track found, and measures its geometric parameters with an accuracy of about 1 μm. Across it the program is adapted for analyzing the track from its origin to the vertex in order to distinguish it from the etched defects and dislocations. The result of the proposed study should be the track-length and track-shape distributions. The chosen methodology is based on measurements of the nucleus track parameters in the course of chemical etching of the olivine crystals and includes the following essential positions:

(a) Geometric characteristics of individual tracks are traced and measured with high accuracy by the PAVICOM complex in the course of their step-by-step chemical etching. The PAVICOM-2 includes a precision-mechanics stage manufactured by the Carl Zeiss company; the LOMO lenses were used, so the measurements are carried out with magnification up to 60^x; a personal computer; a CCD-camera with the relevant hardware and software, which transmits a digital image to the computer. To this end, a method of the layer-by-layer removal of olivine material will be employed, which allows the tracks to be studied over the whole crystal volume under study.

(b) At the initial and subsequent stages of the track revealing, different conditions of the chemical etching will be used, which allows for varying track-etching efficiency within wide limits for VH-, VVH- and heavier nuclei.

(c) The emphasis will be on the measurements of two main track parameters, which determine the nucleus charge: (1) the olivine-crystal etching rate along the nuclear track and (2) the length of the etched cone track within the initial, high-energy section of the track forming and/or the total residual range, corresponding to saturation zone of the primary ionization in a pallasite olivine.

(d) The calibration of the track parameters for the GCR nuclei will be done both experimentally and theoretically. For experimental calibration, similar etching and measurements will be used for track produced in the same olivine crystals by accelerated Xe, Pb, and U nuclei with subsequent extrapolation to the heavier nuclei. In theoretical calibration, the results of the calculation of the specific energy ionization losses for nuclei in the high-energy region will be used, which corresponds to the beginning of formation of chemically etchable tracks.

(e) Checking of the level of possible thermal track annealing in the high-energy zone of the track formation (in spite of extremely low probability of the thermal annealing under space conditions) will be done using both isochrone and isothermal laboratory annealing. Two groups of olivine samples from pallasites will be investigated. (1) Statistically representative number of crystals from meteorites under study, with subsequent analysis and correlation of the characters of the parameter distributions for ancient tracks of the GCL VVH group both for annealed and non-annealed samples. (2) Olivine crystals irradiated by relativistic accelerated ions of Xe, Pb, and U.

(f) The estimate of the expected number of tracks produced by nuclei of the Th-U group and by nuclei with Z ≥ 110 in 1 cm*3 of the Marjalahti pallasite olivine (whose age is about 200 My) is from 300 to 400 and 0.3—1.2, respectively. Therefore, to find a few events of the transuranium nucleus slowing-down and stopping in olivine crystals for this pallasite, an extensive investigation of at least 5 cm^3 of the olivine overall volume is necessary.

Results. Some preliminary results of the GCR VVH-group nuclei charge spectrum is shown in Fig. 1. The values of the track etching rate and the main geometric parameter - total residual track range for the 42 olivine-crystals from the Marjalahti pallasite was measured and used for determination charge (Z) of track-forming nuclei. Time of chemical etching t = 48 hours, in modified WN-solution in conditions: pH = 8.0 ± 0.2, T = (110 ± 1) °C. The track etching rate V_{TR} was determined as RR/ t, where RR – the length of etchable track in the interval of the primary ionisation of the stopping nuclei $(dJ/dx) > (dJ/dx)_C$. The critical value of $(dJ/dx)_C$ is the characteristic parameters for the olivine equal to ~ 18 MeV/ $mg·cm^{-2}$ [4].

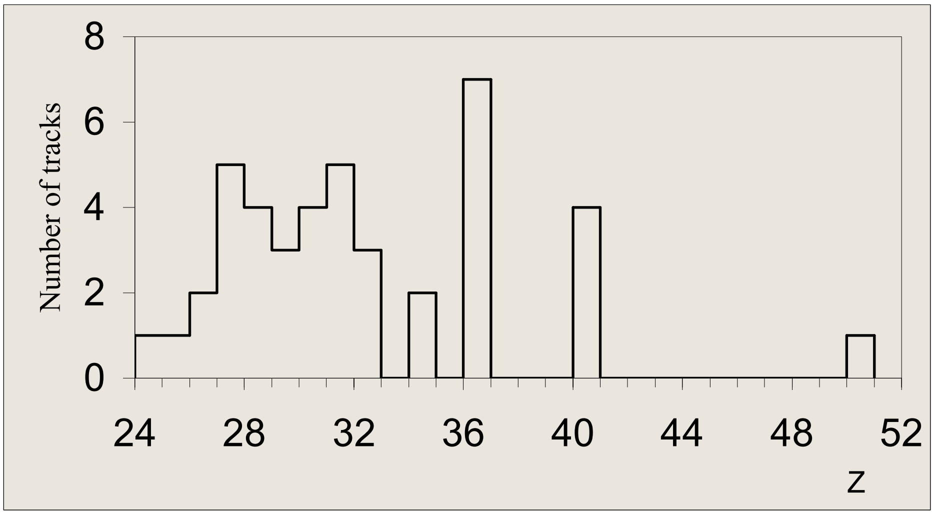

Fig.1. Frequency distribution of the GCR nuclei charge for 42 tracks, etched in olivine crystals from the Marjalahti pallasite

Conclusion. The main novelty of used in our present track investigation methodology consist in: (a) the high-precision measuring of the dynamical (track etching rate) and geometrical (different parts of the track length and diameter) parameters for (b) the preliminary no thermal-annealed fossil tracks, (c) chemically revealed in the pallasite olivine crystals under special etching conditions.

This study was supported by the Russian Foundation for Basic Research, project № 06-02-16835

References

1. *Perelygin V.P., Abdullaev I.G., Bondar Yu.V., et al. //* Nuclear Physics. 2003. A718. PP. 422-424.
2. *Ginzburg V.L., Feinberg E.L., Polukhina N.G., et al.* // DAN. 2005. V. 402. N. 4. PP. 1-3.
3. *Polukhina N.G., Aleksandrov A.B., Apacheva I.Yu., et al.* // Nuclear Instruments & Methods in Physics Research. 2004. A 535. PP. 542-545.
4. *Horn P., et al.* // Zeitschrift fur Naturforschung. 1967. 22 a. N. 11. PP. 1793-1798.

Electronic Scientific Information Journal "Herald of the Department of Earth Sciences RAS" № 1(24)'2006
ISSN 1819 – 6586
Informational Bulletin of the Annual Seminar of Experimental Mineralogy, Petrology and Geochemistry – 2006
URL: http://www.scgis.ru/russian/cp1251/h_dgggms/1-2006/informbul-1_2006/planet-6e.pdf

Published on July, 1, 2006