TO THE PROBLEM OF IDENTIFICATION OF THREE-PRONG TRACK EVENTS DUE TO FRAGMENTS FROM URANIUM FISSION IN PHOSPHATES

[1]Kashkarov L.L., [1]Kalinina G.V., [2]Kravets L.I.
[1] Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Moscow, Russia
[2] Joint Institute of Nuclear Research, Dubna, Russia
ugeochem@geochem.home.chg.ru; phone: (8 252 219-88)

Key words: super-heavy elements, phosphates, pallasites, fission tracks

Introduction

The new approach to a problem of detection of traces of super-heavy elements nuclear decay in the meteorite phosphates assumes in search of cases of spontaneous fission of nuclei with Z ≥ 110 on three fragments of comparable atomic mass [1]. Thus, one of the basic methodological questions is the necessity of the account of magnitude of the contribution in expected density of three-prong tracks in meteoric phosphates from ^{238}U fission fragments [2].

The purpose of the present work is the first experimental research of an opportunity of application of an optical microscope visual search and identification technique for the spontaneous fission cases of super-heavy nuclei on three fragments that can be observed in natural meteorite phosphates.

In the given report the results of track study from spontaneous and neutron-induced fission of uranium in apatite crystals of a terrestrial origin are presented. As in this case probability of detection of real fission of ^{238}U nuclei on three fragments does not exceed $\sim10^{-7}$ in relation to a number of the usual fission acts on two fragments, the experimental detection of three-prong events is the extremely labour-intensive process. It is enough to note, that at average track-density from usual two-prong fission of ^{238}U about (10^5 - 10^6) track × cm^{-2} for detection even one three-prong figure of etching concerning to the real fission act on three fragments, it is need to analyze up to $\sim10^2$ cm^2 of a total crystal surface.

Technique of experiment

The first experimental researches of super-heavy element (SHE) nuclei fission on three fragments were undertaken by V.P.Perelygin in 1980 [3]. Then for the first time it was possible to register some extremely rare events of a three-prong fission of the compound nuclei with Z = 110. These nuclei were formed at a capture by uranium nuclei of the high-energy Ar ions. Received in these researches of a three-prong fission probability in relation to fission into two fragments has made up $\sim3\times10^{-4}$, that on three - four order of magnitude exceeds of a three-prong fission probability of ^{238}U nuclei [4].

However, at realization of search of such rare events in natural silicates it is necessary to take into account the probable background contribution from a number of sources. First of all, to them are related the tracks formed: (a) by fragments of spontaneous fission of ^{238}U and decayed isotope of ^{244}Pu; (b) by nuclei of VH-group of iron (23 < Z < 28) in galactic cosmic rays; and (c) by the fragments from induced under action of primary and secondary nuclear-active galactic cosmic ray particles fission of heavy, mainly Th and U, elements.

Estimation of the contribution value in expected a three-prong fission track-density from spontaneous ^{238}U fission in the pallasite phosphates at uranium concentration of ~ (50 - 100) $\times10^{-9}$ g/g and track-density of spontaneous fission on two fragments equal to ~ (10^5 - 10^6)× cm^{-2} gives value that is not exceeding $\sim10^{-2}$ relative to three-prong events on cm^2 of an chemically etching and investigated crystal surface.

Estimation of probability of background events of a three-prong fission of heavy elements such as Pb, Bi, Th and U, due to primary (p and n) and secondary (n and π-mason) nuclear-active components of the galactic cosmic rays, has shown, that:

a). Contribution from fission of heavy elements on two fragments, induced by the cosmic radiation, become commensurable with the output of spontaneous ^{238}U fission, mainly, at the expense of highly effective fission of ^{235}U nuclei under action of secondary thermal neutrons;

b). Contribution of induced fission of others (Pb, Bi, Au) heavy elements appear on 4-5 orders of magnitude by lower.

Conclusions

As have shown the carried out researches of tracks in terrestrial apatite crystals, viewing, the detection and measurement of track parameters in a superficial layer of researched crystals can be carried out not only with the help of TINT ("track in track" etching) - technique, but also using a simple supervision of tracks leaving on an etching crystal surface.

On common overlooked with the help of optical microscope of the crystal area about 0.5 cm^2 among 7×10^6 registered tracks from the usual two-prong fission was revealed two occurrence with three tracks of different length directed under a corner to each other. The detailed study of these events at higher magnification has shown, however, that these two track figures are formed as a result of casual crossing of two usual two-prong tracks, which have resulted in formation of an apparent three-prong events.

Thus, for the first time determined extreme value of a probability of formation of these apparent three-prong track events made $\sim3\times10^{-7}$ from a number of tracks due to the usual of two-prong fission of the uranium nuclei. It is needed to note, that under the order of magnitude it coincides with theoretical estimations of a $238U^{three}$-prong fission probability [4].

The quantitative estimation of expected surface track-density of three-prong cases due to fission of SHE nuclei was done. It has shown, that in view of the possible contribution of all most essential probable sources of a background at optical scanning not less than ~50 cm^2 of the total crystal area of the pallasite phosphates from some cases of three-prong fission of SHE nuclei can be revealed. The most suitable for these purposes phosphates are the transparent large whitlokite and stenfildite crystals, formed in the pallasite structure.

This work was supported by grant ¹ 01-02-16410 from RFFI

References

1. *Perelygin V.P. et al.* (2002) LPSC XXXIII, CD-ROM, ¹1066.
2. *Kashkarov L.L. et al*. (2004) LPSC XXXV, CD-ROM, ¹1071.
3. *Perelygin V.P. et al.* (1980) Solid State Nuclear Track Detectors. Ed. by H. Francois et al. Pergamon Press, 1980, P. 239.
4. *Herbach C. M.* (2002) Nuclear Physics A V. 712, Issues 3-4. P. 207.

Electronic Scientific Information Journal "Herald of the Department of Earth Sciences RAS" ¹ 1(22)'2004
Informational Bulletin of the Annual Seminar of Experimental Mineralogy, Petrology and Geochemistry – 2004
URL: http://www.scgis.ru/russian/cp1251/h_dgggms/1-2004/informbul-1_2004/planet-3e.pdf
Published on 1, July, 2004