BIOLOGICAL RESEARCHES IN THE DEEP UNDERGROUND FACILITIES OF BAKSAN NEUTRINO OBSERVATORY AND IT'S RELEVANCE TO ASTROBIOLOGY ANALOGUE STUDIES

M. P. Zarubin[1], E. V. Kravchenko[1], K. A. Tarasov[1], A. M. Gangapshev[2], A. S. Yakhnenko[1]
[1] *Dzhelepov Laboratory of Nuclear Problem, Joint Institute for Nuclear Research, Dubna, Russia, mzarubin@jinr.ru*
[2] *Institute for Nuclear Research, Moscow, Russia*

KEYWORDS:
deep subsurface life, Baksan Neutrino Observatory, astrobiology analogue, extremophiles, cosmic radiation

ABSTRACT:
The deep underground laboratories of the physical research centers are highly perspective for conducting biological experiments in the fields of biophysics, radiobiology, astrobiology, microbiology and medicine. Molecular Genetics Group of Dzhelepov Laboratory of Nuclear Problems of the Joint Institute for Nuclear Research (Dubna) initiated collaborative biological research in the tunnel of Baksan Neutrino Observatory (INR RAS, Neutrino village) and in the deep underground low radiation background laboratory (DULB-4900), located 2 km underground, beneath Andyrchy mountain (3937 m. a. s. l.), which is 21.9 km from dormant volcano Elbrus (North Caucasus, Russia).

The biological experiments have been started in December of 2019 [1, 2] and aimed to record for the first time the response to nearly complete absence of natural background radiation at the transciptomic level in the complex model organism – fruit fly *Drosophila melanogaster*. Fruit flies were exposed in low background radiation conditions of DULB-4900 (~16 nGy·h^{-1}) and natural background radiation conditions in the surface building (~190 nGy·h^{-1}), that resulted in more than 10-time reduction of background radiation, and the transciptomic analysis was performed. The results were analyzed through comparative transcriptomic analysis with assumption of effects of various types of stresses. The list of 77 differentially expressed genes was obtained for *D. melanogaster* exposed to low background radiation in DULB-4900 relatively to organisms in the natural background radiation [1]. For fruit flies in DULB-4900, genes, associated with immune response and response to stimuli, were up-regulated, and genes, involved in primary metabolic processes, were down-regulated. Changes in gene expression reflected an adaptive response to conditions of DULB-4900, which are stressful and not typical for terrestrial organisms, possibly due to the chronic lack of external natural stimuli [1]. Further biological experiments are focused on the impact of the cosmic component of natural background radiation and mainly on high-energy or relativistic muons (>1 GeV/c), which are close to atmospheric muons and in this way effects in organism can be simulated. On that goal, experiments are carried out in DULB-4900 of Baksan Neutrino Observatory, which provides almost complete shielding of atmospheric muons, and at muon beam of U-70 accelerator facility of NRC IHEP (Protvino). Notably, the impact of secondary cosmic radiation is an important issue for astrobiology and the study is relevant to many locations in the Universe [3].

Studies of Molecular Genetics Group of Dzhelepov Laboratory of Nuclear Problems is focused on natural mechanisms of extreme stress-resistance [4], due to this another branch of biological researches in Baksan Neutrino Observatory is dedicated to studies of deep underground microorganisms surviving in 2-km-deep granitic rocks. Studies of Deep Life (>1 km) reveal one of the less investigated ecosystems on Earth, which has an outstand-

ing potential for astrobiology analogue researches [5, 6]. Baksan Neutrino Observatory is one of the deepest easily-accessible locations in North Caucasus and Russia and, notably, it is in proximity to Elbrus Volcanic Center. Our group performs metagenomic analysis of the biofilm community of deep underground mineral spring. The study was accomplished by the cultivation of some microorganisms and have already lead to the discovery of several novel genera and species of bacteria [7]. The exploration of unique microbial communities in Baksan Neutrino Observatory is an opportunity to discover one of the deepest microbiomes ever studied in North Caucasus and Russia, which can contribute to studies of the global distribution of life in deep underground environments. In conclusion, this study outlines that deep underground locations of Baksan Neutrino Observatory are perspective as the astrobiology relevant-site.

REFERENCES:

[1] *Zarubin M., Gangapshev A., Gavriljuk Y. et al.* First transcriptome profiling of *D. melanogaster* after development in a deep underground low radiation background laboratory // PLoS One. 2021. V. 16. No. 8. DOI: 10.1371/journal.pone.0255066.

[2] *Zarubin M. P., Kuldoshina O. A., Kravchenko E. V.* Biological Effects of Low Background Radiation: Prospects for Future Research in the Low-Background Laboratory DULB-4900 of Baksan Neutrino Observatory INR RAS // Phys. Part. Nucl. 2021. V. 52. No. 1. P. 19–30. DOI: 10.1134/S1063779621010056.

[3] *Ferrari F., Szuszkiewicz E.* Cosmic rays: A review for astrobiologists // Astrobiology. 2009. V. 9. No. 4. P. 413–436. DOI: 10.1089/ast.2007.0205.

[4] *Zarubin M., Azorskaya T., Kuldoshina O., S. Alekseev et al.* The tardigrade Dsup protein enhances radioresistance in Drosophila melanogaster and acts as an unspecific repressor of transcription // iScience. 2023. V. 26. No. 7. Article 106998. DOI: 10.1016/j.isci.2023.106998.

[5] *Onstott T. C. et al.* Paleo-Rock-Hosted Life on Earth and the Search on Mars: A Review and Strategy for Exploration // Astrobiology. 2019. V. 19. No. 10. P. 1230–1262. DOI: 10.1089/ast.2018.1960.

[6] *Bashir A. K. et al.* Taxonomic and functional analyses of intact microbial communities thriving in extreme, astrobiology-relevant, anoxic sites // Microbiome. 2021. V. 9. No. 1. DOI: 10.1186/s40168-020-00989-5.

[7] *Tarasov K. et al.* Cytobacillus pseudoceanisediminis sp. nov., A Novel Facultative Methylotrophic Bacterium with High Heavy Metal Resistance Isolated from the Deep Underground Saline Spring // Curr. Microbiol. 2023. V. 80. No. 1. P. 31. DOI: 10.1007/s00284-022-03141-8.