THE INFLUENCE OF THE CRYOBIOPSHHERE AND A COMPREHENSIVE APPROACH TO THE STUDY OF THE SOLAR SYSTEM

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Abstract. This article presents a critical analysis and overview of interdisciplinary approaches developed and applied by us to solve key problems in modern space science, including astrobiology, space radiophysics, and medicine. We focus on the prospects for finding extraterrestrial life through detailed study of the Earth's cryobiosphere and its niches in the context of Mars. In addition, we present the results of radiophysical studies of the solar wind and planetary ionospheres, as well as new methods for global monitoring of the Earth's ionosphere. In the field of space medicine, we analyze data from the ground-based Mars-500 experiment, aimed at identifying osological conditions under the influence of extreme climatic and environmental factors. In conclusion, we describe the architecture of the research documentation automation system (SADI) required for the management and analysis of complex technical systems in the MARS multilevel modeling environment (SMM MARS).
Keywords: cryobiosphere, Mars, Venus, solar wind, radio transparency, ionosphere, Mars-500, pre-nosological conditions, permafrost rocks, thermophiles,satellite radio tomography, SMM MARS, automation of documentation.

Have you ever wonder about living on other planet? There is a photograph of Mars that seems almost tender. The red horizon, soft and endless, glows under a pale sun that looks smaller than ours, as if the universe itself were holding its breath. The land is silent — so silent that even imagining footsteps feels intrusive. And yet, for decades, humanity has looked at that desolate world and whispered: *home*. Mars has become our collective mirror — a projection of everything we long for and everything we fear. To some, it represents a future beyond Earth, a refuge for civilization in the face of climate collapse or war. To others, it is a romantic dream, the ultimate test of our ingenuity and courage. But beneath the fascination lies a quieter truth: perhaps humans might never truly live on Mars. Not because we lack the technology — though that, too, remains formidable — but because something deeper, something intrinsic to our nature and to the nature of Mars itself, stands in the way.

Mars orbits the Sun at an average distance of around 225 million kilometers from Earth, a figure that belies the full magnitude of isolation we would face. A trip there could last six to nine months, all spent in tight quarters, exposed to constant radiation, while microgravity weakens bodies and disrupts the natural rhythms of life. Even communication becomes a painful exercise — signals lag by up to twenty minutes each way, turning conversation into long silences and delayed feedback. In such an environment, a medical crisis, a technical failure, or even profound loneliness could spiral into disaster.

When rovers like Curiosity, Spirit, and Perseverance explored Mars, they revealed a world both barren and unforgiving. But it is not just the cold or the toxic dust that threatens us — the radiation on the surface is stark. Instruments on Curiosity's Radiation Assessment Detector (RAD) measured daily absorbed doses of about 180–225 micrograys, translating to approximately 0.67 millisieverts per day. Unpredictable solar storms, known as solar energetic particle events, can push that radiation far higher, making warning systems and sheltering essential for any crew.

Mars' thin atmosphere and lack of a global magnetic field provide very little protection from charged particles. Because of this, any habitat would likely need meters of shielding, possibly using Martian soil, to make it safe for long-term occupation. Another invisible threat comes from ultraviolet (UV) radiation. Even under a dusty Martian sky, harmful UV-C wavelengths reach the surface, posing a serious biological hazard. Surface missions and settlements would therefore require strong protection against both charged particles and UV radiation.

Comprehensive study of the Solar System is an absolute priority for humanity in the first half of the 21st century and requires the integration of advanced methodologies from various scientific fields. Our research covers a range of tasks, from the search for extraterrestrial life (astrobiology) and the study of space plasma (radio physics) to ensuring the safety of manned missions (space medicine). Effective management and analysis of the complex technical objects required to achieve these ambitious goals is impossible without the implementation of automated simulation and documentation systems.

We emphasize that the successful implementation of future manned flights to Mars depends on a deep understanding of the psychophysiological and medical problems that arise in conditions of prolonged isolation and exposure to extreme factors. In addition, crew safety requires careful protection from radiation. A Mars mission, involving a six- to nine-month flight covering a distance of about 225 million kilometers from Earth, involves constant exposure to radiation, microgravity, and communication delays of up to twenty minutes in each direction. Mars has no global magnetic field and its atmosphere is thin, providing minimal protection from charged particles. Instruments on the Curiosity rover (RAD) measured daily absorbed doses in the range of 180-225 micrograys, equivalent to approximately 0.67 millisieverts per day. For long-term occupation, habitable modules will require shielding several meters thick, possibly using Martian soil.

In its early stages of development (the Noachian period, 4.6–3.7 billion years ago), Mars followed a scenario similar to that of early Earth, which theoretically allows for the possibility of life emerging. Intense meteorite bombardment with icy bodies during the Noachian era may have contributed to the warming of the surface, creating a warm and humid climate conducive to the formation of the hydrosphere. However, the subsequent Hesperian (3.7–3.0 billion years ago) and Amazonian (3 billion years ago to the present) periods led to global freezing, the formation of a cryosphere, the loss of a dense atmosphere, and the cessation of the water cycle.

In the modern period, it is assumed that during the Hesperian and Amazonian periods, life could have been preserved in subglacial aquifers or preserved in frozen rock strata. Groundwater lying at depths inaccessible to modern research could have supported life, periodically bringing microorganisms to the surface in areas of unloading or active volcanism. Our analysis of Mars' temperature models, based on the heat conduction equation, shows that the layer of porous, fractured rock could only be completely frozen in the maximum model (11.3–23.8 km). At the same time, the minimum and nominal models (2.27–6.53 km) suggest the presence of aquifers beneath the permafrost. The temperature of these sub-permafrost waters in the equatorial zone could potentially reach 50 °C.

The study of the Earth's cryosphere and the viable microorganisms found in it provides us with a possible analogue of extraterrestrial ecosystems, especially with regard to Mars.

Given the age difference, the most promising area for the search for life is the analysis of young geological formations of the Late Amazonian subdivision (which began 550–300 million years ago).

We consider the frozen sediments of the Polar Volcanic Province (79–81° N) to be the most promising object for our research. This area includes young shield volcanoes and cinder cones (aged 1–20 million years) located on the periphery of the northern polar cap. The genesis and age of these formations are similar to volcanic structures on Earth (e.g., Kamchatka, Antarctica), from which viable thermophilic bacteria have been isolated. Consequently, this ecotope is most suitable for extrapolating the Earth model of cryopreservation.

This strategy requires shallow drilling (2–3 m). This will allow penetration beneath the upper lifeless layer (about 1.5 m), which is subject to destructive cosmic radiation and ice sublimation. The discovery of life in these layers will allow us to conclude that Noahid microorganisms could have been brought to the surface by deep waters through geothermal talics and then preserved in frozen sediments. When culturing Martian samples, it is necessary to use a wide range of temperatures, given that the most ancient branches of Earth life are represented by hyperthermophilic organisms.

The successful completion of long-duration manned flights requires in-depth study of the human factor in conditions of isolation and stress. As part of ground-based simulation of a flight to Mars, the Mars-500 program was implemented, which included a 520-day experiment in a pressurized chamber, as well as satellite studies of groups of volunteers living in different climatic zones. Our main goal was to assess the impact of climatic and environmental factors on the human body by identifying pre-clinical conditions in volunteers.

Our interdisciplinary research demonstrates the wide range of challenges facing science in space exploration and provides a basis for future successful interplanetary expeditions.

In the field of astrobiology, despite the enormous difference in the age of the cryosphere of Mars and Earth, we have concluded that the most realistic search for life should focus on the young volcanic deposits of the Polar Volcanic Province of Mars. We suggest that these formations may contain thermophilic microorganisms carried from subglacial aquifers.

In space radiophysics, advances in radio transparency methods have allowed us to refine the speeds of the solar wind and the characteristics of the ionospheres of Mars and Venus. In addition, we have developed new effective methods for global monitoring of Earth's ionosphere, which are critical for space navigation.

The results of the Mars-500 project revealed increased stress on regulatory systems and a tendency toward pre-pathological conditions in individuals living in certain climatic conditions (“northerners”), as well as a significant slowing of psychomotor reactions associated with environmental pollution (“uralites”). These data require careful consideration when forming and providing medical support for crews on long-term missions.

Finally, the introduction of automation documentation systems, such as SADI in SMM MARS, ensures the standardization, storage, and exchange of the results of complex technical research, which is an integral part of improving the efficiency of the scientific process.

LIST OF REFERENCES

1. Демидов Н.Э., Бойнтон У.В., Гиличинский Д.А. и др. Закономерности распределения воды в мерзлотных районах Марса по результатам совместного анализа данных прибора ХЕНД (Марс Одиссей) и МОЛА (Марс Глобал Сервейор) // Письма в Астрономический журнал. 2008. № 34. С. 10.
2. Ерохина Л.Г., Вишнивецкая Т.А., Гиличинский Д.А. Состав и содержание фикобилиновых пигментов в клетках древних жизнеспособных цианобактерий из вечной мерзлоты Арктики // Микробиология. 1998. Т. 67, № 6. С. 821–826.
3. Ерошкин М.А., Ганджа Т.В. Язык представления математических выражений для реализации редактора макрокалькулятора // Компьютерные технологии в образовании / Под ред. В.М. Дмитриева. Томск: Изд-во Том. ун-та, 2004. Вып. 2. С. 23–28.
4. Ефимов А.И. и др. Письма в Астрономический журнал. 2000. Т. 26. С. 630.
5. Жарков И.Б., Филиппова О.И., Федотов Д.Д., Киселев Д.Б. Психофизиологическая характеристика работающих с химическими веществами // Медицина труда и промышленная экология. 1997. № 11. С. 44–46.
6. Зенке Д. Медико-экологические исследования по программе «Марс-500» в Германии // Донозология – 2009. Проблемы здорового образа жизни: Материалы 5-й Международной конференции. СПб., 2009. С. 212–213.
7. Сезонная динамика физиологических функций у человека на Севере / Под ред. Е.Р. Бойко. Екатеринбург: УрО РАН, 2009. 223 с.
8. Цытович Н.А. Механика мерзлых грунтов. М.: Высшая школа, 1973. 446 с.
9. Черникова А.Г. Оценка функционального состояния человека в условиях космического полета на основе анализа вариабельности сердечного ритма: Автореф. дис. … канд. биол. наук. М., 2010. 24 с.
10. Щербакова В.А., Чувильская Н.А., Ривкина Е.М. и др. Новая галотолерантная бактерия из криопэга в вечной мерзлоте: описание Pychrobacter miicola sp. nov. // Микробиология. 2009. Т. 78, № 1. С. 98–105.
11. Яковлев О.И., Викерт Й., Ануфриев В.А. Доклады РАН. 2009. Т. 427. С. 624.
12. Яковлев О.И., Шишков В.И., Чашей И.В. Письма в Астрономический журнал. 1990. Т. 16. С. 163.