ASTRONOMY

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USING ARTIFICIAL INTELLIGENCE FOR EXPRESS-ANALYSIS OF THE BIOTIC POTENTIAL OF ALIEN HABITATS

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Abstract

The article discusses the possibilities of using artificial intelligence to quickly determine the potential of the surface of rocky planets for the spread of biota. These ideas can be implemented to optimize and improve the efficiency of the search for life beyond Earth. They also increase the level of protection of the aboriginal biota of other planets and allow to speed up the planning stage of terraforming.

Keywords: terraforming, modeling, exoplanets, astroecology, extremophile.

Modern astrobiological studies illustrate the transition from the period of romance to the era of pragmatism. A hundred years ago, researchers, engineers, and other interested parties believed that it was enough to touch the surface of other cosmic bodies, as we will immediately receive numerous contacts with highly developed and intelligent life. The era of practical space exploration began in the second half of the 20th century. Space engineers were faced with several important tasks. The first was an ordinary engineering task, to make an apparatus that would be able to land on other objects of the Solar System with a high probability. However, everyone wanted more. Echoes of the previous era of Romanticism left an imprint on the specifications of the equipment that was installed on the first interplanetary stations. Together with devices for visual fixation of the surface of the planet and analyzers of physical and chemical parameters, numerous machines were used that could determine the presence of life.

For example, the «Viking» program had the dominant astrobiological purpose [4]. It was supposed to be a logical conclusion of the previous studies of Mars by the devices of the «Mariner-Mars» series («Mariner-4», 1964; «Mariner-6» and «Mariner-7», 1969; «Mariner-9», 1971-1972). Both «Vikings» were launched in 1975. They were supposed to work as two units - orbital and on the surface of Mars. Orbital «Viking-1» worked until August 7, 1980, and its lander until November 11, 1982. The orbiter «Viking-2» operated until July 25, 1978, and its unit on the surface – until April 11, 1980. Before the flight, both devices were well sterilised. As modern studies show, such measures are not always effective enough [13]. Recently, a group of microorganisms was found that can exist even in the aggressive environment of wipes used to disinfect space vehicles [2]. In this case, there were three types of risks. First, the device can establish the presence of biota by finding it in the "dirt" brought with it [5]. Secondly, it will pose a threat to the aboriginal biota, which may not be able to withstand competition with earthly biota [3]. Thirdly, terrestrial biota can spread throughout the planet, and we will finally lose the opportunity to get an answer to the fundamental question of what life is [8].

There are two television cameras with a circular view, a seismometer, meteorological instruments for measuring temperature, pressure, direction, and wind speed, an X-ray fluorescence spectrometer, a mass spectrometer combined with a gas chromatograph, and a special installation for searching for life in the soil on the apparatus «Viking» series. The last two blocks were responsible for finding life. The first identified the presence of organic substances by molecular weight, and the second was to determine the presence of photosynthesis and metabolism. Then and now, the question arises - what is the probability of taking a sample in an area devoid of life, next to one filled with chemotrophic biota? Researchers of terrestrial deserts will say that it is extremely large. After all, our deserts are also not covered with a continuous carpet of alhagi or cacti. In extreme Martian or other extraterrestrial conditions, there can be a high degree of mosaicism in the distribution of biota.

The «Vikings» received a large amount of information about the chemical composition and chemical activity of the soil, which turned out to be higher than predicted. For example, a 15-fold increase in oxygen release was found, which can be explained by chemical reactions in iron-rich soil. Also, in the nutrient medium with labelled atoms, an increase in carbon dioxide to a level equal to that of the Earth was observed. Another experiment showed ambiguous results related to the absorption of carbon ^{14}C - it was either assimilated or not. However, the «Vikings» did not notice a significant number of high molecular weight organic compounds. After the discovery of perchlorates in the Martian soil as part of the «Phoenix» mission (2008), experiments were conducted with their addition, similar to «Vikings» on Earth. They gave similar results. Therefore, in the sampling area, there was either a very small number of living creatures or they were completely absent. So we can assume that these samples were taken in a not quite good place. Thus, the question arises as to how to choose a sampling site with a higher probability of unequivocal results. Until we have sufficient empirical experience, we will have to develop algorithms for the search for life on the surface of space objects, relying on existing theoretical models [7].

A popular method today is the use of biosignatures or making direct analogies with the terrestrial habitat of biota. This method is imperfect and retains the potential for the existence of erroneous algorithms. After all, both approaches are based on observations of biota originating from the same life form. Here we face the problem of generalisation based on a small variety of observed objects. After all, we cannot be completely sure whether our generalised ideas about the biochemical and biophysical characteristics of life, built based on the study of the Earth, apply to life in general.

Considering the above, we have to create models of habitats that are more or less suitable for the development of chemotrophic extremophilic biota [9]. The next step is to develop methods for rapid assessment of these environments, which will allow automated missions and their operators to adjust search efforts directly on the surface of the space object. One of the most promising solutions is the use of artificial intelligence to analyse substrate images. At the same time, the ideal option is to automatically recognize it without frequently sending these images to Earth.

The basis for the model of the potential distribution of biota on the surface of rocky planets and their satellites is the size of the mineral particles of their soil [1]. This pattern will work if the chemical parameters of the soil and the microclimate above it are constant. This feature is due to the features of loose sedimentary rocks. The sizes of their particles determine the volume of the internal space of the soil, as well as its capillary properties. Too large spaces between mineral components reduce the capillary area and water with dissolved mineral salts will quickly leave the soil. This will occur due to active movement in the form of underground flows or evaporation in the near-surface layer, which will cause a too low or too high level of motility of microorganisms and the substrate they need. This will directly affect the concentration of biota representatives [10]. By analogy with terrestrial conditions, we believe that optimal soil conditions form substrates with particle sizes close to the eolian loess of Ukrainian Polissia [6]. These are dust particles with a size of 0.05 to 0.005 mm (up to 60%), clay particles with a size of less than 0.005 mm (up to 10-20%), and sand particles with a size of 0.1-0.25 mm (up to 7%).

Today, there are technologies for determining the size of particles of loose rocks based on their usual images of moderate quality [11]. This allows the automated research complex to obtain data on the potential concentration of hypothetical biota on or under the investigated soil surface within a few seconds. For this, artificial intelligence systems are used, which participate in the analysis of the newly created image [12]. This will make it possible to determine the most promising areas in the area available for sampling. Thus, we will not only save scarce resources but also make the search for biota more reliable and high-quality.

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