ASTRONOMY

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THE INFLUENCE OF SUBSTRATE PARTICLE SIZE ON THE POTENTIAL FOR SPONTANEOUS SPREAD OF BIOTA ACROSS THE LANDMASS OF ROCKY PLANETS

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Abstract The article discusses the possibilities of using hyperspectral imaging to determine the potential of areas for the spread of biota on the surfaces of rocky planets. This is of practical importance for the search for life outside the Earth, protection of aboriginal alien biota, increasing the efficiency of methods of its search and, in the future, increasing the efficiency of terraforming.

Keywords: terraforming, panspermia, hyperspectral imaging, exoplanets, astroecology

One of the key features of matter is its ability to exist in certain environmental conditions for a certain time. From the very moment of the Big Bang, the evolution of all the universe objects takes place according to this definition. Initially, the main existence strategy of those elements was resistance to the pressure of the external environment and internal destructive changes. However, with the complexity of the structure of material objects, new survival strategies appeared. Over time, it became possible to preserve not the individual integrity of objects, but their shape due to an increase in the number of similar objects. This is how life arose, the main strategy of which was to preserve a certain form of an object by increasing the number of its copies. From that moment on, the evolution of the universe followed a new path - the improvement of the processes of reproduction of its own kind and the conquest of new spaces by them. An increase in the number of organisms and the area of their habitats are fundamental signs of life.

When the biota inhabited the entire surface of the Earth, it faced a difficult barrier to overcome - outer space. There was and still is a possibility that certain living organisms will fall into open space during a collision with a meteorite. However, we have to take into account the physical parameters of such an event and the probability of their further meeting the necessary conditions on another planet. The probability of this spontaneous panspermia seems very low.

At the same time, the launch of spacecraft beyond the Earth's orbit makes the increased risks of life transfer quite significant. Despite all safety measures, hundreds of extremophiles may remain on interplanetary spacecraft [2]. As the latest experiments show, they are able to survive both on the surface of ships and on the planets where these ships are moving [15].

The transfer of organisms beyond their historical range often results in environmental problems even on Earth. We have a number of disasters of various types as a result of alien species invasions. This can not only pose a threat to biodiversity and aboriginal biota but also cause economic losses (weeds, pests of forests and agricultural crops) or threaten the life and health of people (*Ambrosia antemisiifolia* L., *Heracleum sosnowskyi* Manden. and others) [5].

The transfer of living organisms outside the planet can carry similar risks [4]. First, they pose a threat to indigenous alien biota. It is theoretically impossible to predict the competitiveness of organisms, one group of which exists only hypothetically. Terrestrial biota may turn out to be more adapted to certain environmental conditions and transform in such a way that the aboriginal biota will be destroyed or its biodiversity will be significantly reduced. It should be taken into account that there are mostly no phototrophic highly organized organisms on the planets that are available to us for study. So, unlike our autotrophic extremophiles, they did not survive the Oxygen Catastrophe and do not have the appropriate adaptations. Thus, the risks of their destruction increase significantly. Such events caused by cosmic expansion are not only unethical [12]. From the point of view of modern environmental ethics and is a significant blow to our worldview and cognitive sphere [3]. After all, while we are dealing with life from only one planet, our ideas about life as a whole are completely hypothetical. The lack of a holistic view of life carries potential threats to ourselves, which are also part of it. The presence of earthly life, accidentally transferred by man, on the surface of other planets or their satellites completely nullifies the scientific search for extraterrestrial life. After all, we lose the opportunity to study not only the biota that was formed in other conditions but also the processes of panspermia [7].

In addition to the theoretical aspect of anthropogenic panspermia and spontaneous terraforming, there are a number of practical problems. First of all, such a movement can pose a direct threat to colonists or residents of space stations. After all, among the biota that uncontrollably travels with us, there may be dangerous or potentially dangerous organisms for humans [13]. Their influence in the conditions of a comic space, on a small and partially isolated group of people can be catastrophic [14]. Also, there may be a threat to the biota cultivated by humans in their extraterrestrial settlements for scientific or consumer purposes [11].

On the other hand, when it comes to uninhabited planets that need to be terraformed for human habitation, such spontaneous panspermia and terraforming can be extremely useful. They will greatly speed up and cheapen the transformation of a planet intended for colonization. Spontaneous restoration of ecosystems in uninhabited areas has considerable potential for use. The main task in this case is the ability to model these processes in order to have the opportunity for their prediction, correction, and acceleration. For this purpose, the basic regularities of spontaneous panspermia and terraforming should be established, as well as confirmed in experiments or field observations.

With the constancy of climatic factors and chemical characteristics of the edaphotope, the key factor will be the particle size of its substrate. This is due to the potential of converting loose sedimentary rocks into soils. The fact is that highly organized biota cannot exist without soil. Even extremophile plants that grow on rocks or in deserts depend on small volumes of soil that form between mineral rocks. Soilless substrates are filled mainly by unicellular or colonial organisms, as well as mosses and lichens. Since the size of mineral particles affects the formation of capillaries where water, dissolved minerals and dead organic matter are located, many life forms of mosses and lichens will also be limited by a certain size of substrate elements. For example, most terrestrial mosses and bushy forms feel better on a loose substrate. As shown by laboratory experiments and field observations, an ideal mineral substrate from the point of view of formation of capillary moisture reserves and transformation into soils is eolian loess with particles of 0.005 mm - 0.05 mm in size [8].

We can assume that the alien aboriginal biota is also distributed unevenly on the surface of the planets. Therefore, there are areas where it is more likely to be found and those where it is probably absent. If we are talking about extremophile chemotrophs whose environmental conditions did not lead to global changes in the exobiosphere, then this trend will be more pronounced. Thus, it is rational to search for aboriginal biota outside the Earth's borders in territories with a substrate close to loess or tiny sand.

Determining potential sites for the establishment of native or invasive biota will not require cumbersome instruments on research vehicles. Today, there is no need to use a set of traditional sieves to distribute the mineral components of the substrate. This task is currently being handled by photometric methods [9]. The use of hyperspectral imaging with the use of artificial intelligence for image processing shows good results. Our analysis of average-quality photos may be sufficient to obtain data on particle sizes too [10]. Verification of the method on model objects within the boundaries of the Earth gives good results. We chose quarries in the territory of Central Polissia (Ukraine) as a model object [1]. Restoration of vegetation in quarries differs from alien spontaneous terraforming only by the power and diversity of the flow of biota rudiments [6]. Since we manage to make good predictions for the restoration of ecosystems on the disturbed surface of our planet, there is a high probability of successful application of these methods beyond its borders. Such an approach will help to significantly speed up the process of finding life on other planets, improve the definition of the most vulnerable regions for invasions of terrestrial biota, and develop more effective methods of terraforming planets chosen for colonization.

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