On the Path to Space Mining and a Cosmic Sustainable Way of Socio-Natural Interaction

Arkady Ursul

Doctor of Philosophical Sciences, Professor,
Academician of the Academy of Sciences of Moldova,
Lomonosov Moscow State University (Moscow, Russia)
E-mail: ursul-ad@mail.ru
https://orcid.org/0000-0003-2643-5558

Tatiana Ursul

Doctor of Philosophical Sciences, Professor,
National Research Technological University “MISiS” (Moscow, Russia)
E-mail: ursult@mail.ru
https://orcid.org/0000-0002-4520-9487

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The transition of the world community to sustainable development will require not only the achievement of global sustainability, but also the same type of development outside the planet, especially in the case of space mining. By joining the cosmonautics, sustainable space mining will contribute to the formation of an extraterrestrial basis for the future wide exploration of space by mankind and a new way of social and natural interaction. This will be, on the one hand, a continuation of earthly material production, but on the other hand, a completely new process due to the interaction of man with the extraterrestrial environment. A mode of production will begin to take shape, increasingly different from the current “planetary-production” way, which is appropriate to give the name of “production — cosmic” and the main features of which have yet to be identified. However, since humanity will simultaneously continue to inhabit the planet and settle beyond it, the aggregate way of interaction between nature and society will be their mutual earth-space combination (complex).

Keywords: space resources, space mining, cosmonautics, planetary and production way of evolution, production and space way of development, way of social and natural interaction, sustainable development

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Introduction

After the United Nations Conference on Environment and Development (UNCED) in 1992 in Rio de Janeiro, the world community set a goal and adopted a strategy for transition from spontaneous to globally managed sustainable development (SD) as the main way of civilization survival. A definition of the SD concept was given in the book "Our Common Future," known as G.H. Brundtland, and devoted to the scientific substantiation of the need for the transition to SD. It was drawn to the future: "Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission, 1987: 54). Thus, in particular, was defined as the main goal of the necessity of transition to sustainable development — the future survival of mankind.

Preservation of the biosphere and survival of mankind is the cardinal purpose of the transition to sustainable development. The best-case scenario for the future of our planet and mankind living on it involves the preservation of the biosphere as the natural basis of life of all the living and sophont (Bobylev, 2017).

Moreover, this includes the life of the population and a significant part of the biodiversity in such vulnerable ecosystems as mountainous regions (for example, 43 constituent regions of the Russian Federation have mountain ranges and uplands, and the total area occupied by them is 53.6% of the territory of Russia). The mountains occupy about one-fourth of the planet's surface and are home to 12% of the world's population. They affect all processes in the rest of the planet. Mountainous areas are important for the existence of civilization, and for the evolution of the entire global ecosystem, which was highlighted in the Agenda 21 adopted by UNCED.

Mountainous areas more than other habitats are affected by the adverse effects of climate change, as well as the consequences of disasters in mountainous areas, such as flash floods, including floods from mountain lakes, as well as landslides, mudflows and earthquakes. At the same time, the mountains are sources of mineral resources and sources of fresh water supply, as well as hydropower resources (70% of fresh water reserves and 50% of deposits of precious and non-ferrous metals are concentrated in the mountains).

This feature of mountainous areas requires severe special restrictions on economic activity and the implementation of "sustainable mining development" (Resolution, 2007). Therefore, in the documents of the UN dedicated to SD strategy, special attention was paid to the mountainous areas. Mountainous regions are characterized by the fact that they are one of the most ecologically vulnerable areas, and at the same time, they are the ones that are affected by the development of the most large-scale environmental management processes that cause negative impacts on the surrounding nature and people. "Sustainable mountain development" and "sustainable development of mountainous areas," although close, but not the same concepts. The latter concept focuses on mountainous areas, while the term "sustainable mining development" characterizes SD as mountainous areas and other territorial areas where sustainable mining can take place, for example, on plains or even outside the planet. This difference appears due to the fact that mining is associated not only with mountains and hills, but with a special human activity in the development of the Earth's interior in any other place on the planet, i.e., underground mining of minerals. Therefore, mining as an activity for the development of the Earth's interior allows both its planetary-terrestrial and cosmic expansion.

Mining, as a rule, is considered as a field of activity on the use of the Earth's crust for the extraction of minerals, their primary processing, as well as related scientific research.

However, this term has recently become used not only in the meaning of mining, but in the production of bitcoins and other crypto-currencies on mining farms and platforms. In the article, the concept of mining will be used in the context of mining, rather than crypto-currency. Thus, a number of key concepts that originated and were used in the mining engineering receive their new, space and information, expansion. Humanity is now interested in mining SD not only in the "planetary-underground," but also in the space perspective since in the future, these two processes will occur not only in parallel, but also cooperatively. Although the journal has already considered possible ways of further development of the mining industry, for which non-standard ideas and forecasts of scientists and entrepreneurs are used, however, we will continue these ideas in the cosmic dimension.

SD can be implemented in two main variants — in the global-terrestrial one, in accordance with a modern concept, and space one, as proposed by the founder of astronautics, Konstantin Tsiolkovsky (Tsiolkovsky, 1954). In the article, continuing the ideas of Tsiolkovsky, we will talk about the formation of a new method of socio-natural interaction, different from the "planetary-production" method, due to the interaction of man with the extraterrestrial environment, which is appropriate to give the name "production and cosmic way."

Sustainable Horizons of Extraterrestrial Mining

The beginning of the interaction between mining engineering, mining, and astronautics did not come by accident at the present time of space exploration. It became obvious that space activities would not continue to develop effectively without the "support" of the mining industry and its emergence beyond the terrestrial atmosphere. Along with this, both further space exploration and geospace safety promotion, i.e., protection of the planet against threats from space, will be impossible without the development of space mining. It is appropriate to recall that Konstantin Tsiolkovsky proved the necessity of space exploration proceeding not only from the demands of social and economic development but primarily from the need to ensure the safety and preservation of mankind. He also reckoned the emergence of an "industry in the ether." Therefore, the development of mining, and through it, the other industries, is in line with the reduction of anthropogenic pressure on the biosphere under the conditions of the population growth.

The development of space resources and their processing outside the Earth, directly in space, drastically changes the principles and trajectories of space missions, as well as the ways of creating space technology, bringing this technological process beyond the biosphere. The priority of space resources is water. It can be found in circumterrestrial asteroids in the amount of several trillion tons. If it becomes possible to extract water from natural cosmic bodies (which decomposes under the influence of an electric current to oxygen and hydrogen) and other necessary products for space technology and to produce fuel outside the planet on the basis of hydrogen, it will reduce the price of further space development by twenty times.

It is believed that the first space field is likely to be not asteroids (which may contain rare earth elements, platinoids, and other rare and precious metals) but the Moon, where the priority extracted resource will be the water used to provide life support to people and fuel for rockets and space vehicles. The need to use lunar natural resources for the creation of lunar bases, the construction of space infrastructure for the purposes of further space exploration, including mine shafts, tunnels and other underground structures, especially for refueling space vehicles, attests to the early development of the Moon (Krichevsky, 2020; Krichevsky & Bagrov, 2019; Mayboroda, 2018; Slyuta, 2017).

However, more than a thousand asteroids are flying near the Earth, and they can be achieved much more easily than the Moon. At the same time, some of them represent a very serious threat to our planet, which is often reported by the media. However, the Moon still does not significantly affect the problem of geocosmic safety, while some asteroids and comets constitute a threat to the planet on a short-term horizon. It is evident that the asteroid-comet hazard has to be prevented, and it can fundamentally affect the choice of further ways and methods of space activities since security is always more important than commercial and other activities. In fact, it is also necessary to stand secure in order to develop the economy.

The basic idea of SD in its terrestrial and space variants is to ensure the safe existence of mankind (Ursul, 2016). It is important not to place in jeopardy the ability of future generations to meet their needs and, above all, the basic need for a safe existence and sustainable development on the Earth and in space. After all, the more space and objects of space will be mastered on a larger scale, the greater the chance of a further continuation of mankind existence (Ursul & Ursul, 2019).

Konstantin Tsiolkovsky assumed the idea of creating his space version of sustainable development beyond the planet. The recently deceased British physicist Stephen Hawking and American entrepreneur Elon Musk, who founded SpaceX company in 2002 in order to colonize Mars, came to the same ideas. This colonization, in his opinion, will turn mankind into a multi-planetary species and increase the probability of the survival of our civilization if some global space catastrophe occurs on Earth (Musk, 2017). Space mining can be the "key" to survivorship, which will destroy (or deflect from the planet) a dangerous asteroid, as it was already in art form demonstrated in the American fantasy film "Armageddon" at the end of the last century.

It is important to pay attention to a kind of "reverse effect" of new mining technologies developed for space needs: many traditional mining technologies cannot be used in the space mining industry since space conditions fundamentally affect these technologies. The application of new physical principles and fundamentally new approaches to the creation of equipment will be required for space mining technologies. For example, in the future, there may be technologies for direct metal extraction, bypassing mining, processing, and metallurgical processing, as is customary in "terrestrial" mining technologies. These new technologies seem to be more cost-effective in terms of the cost-benefit ratio, but what counts most is that they are environmentally friendly and less material-intensive. This makes them more acceptable in case of implementation in terrestrial conditions, so the space mining options will significantly contribute to the transition to mining SD on a global scale.

Mining space technologies in the conditions of our planet in the coming decades can have a revolutionizing effect on the entire terrestrial mining industry. Therefore, when there arises an image of the mine of the future, it is important to consider the possibility of deploying space mining and its influence on underground works and structures.

Paying attention to the problem of material intensity, one should not overlook the energy problem, which is more fundamental and acts as one of the main ones in the process of transition to the SD. It is known that over a million tons of helium-3 isotope accumulated in the surface layer of the lunar soil (the regolith), which can be used as fuel for future thermonuclear reactors and which is sufficient to provide humanity with energy for many thousands of years. Since such fuel produces few carbon and toxic wastes, its environmental benefits attract the attention of power engineers, and because of the helium-3 isotope, in the not too distant future, the Moon can become one of the main space mines.

However, it is unlikely that the entire stock of these energy commodities will be sent to the planet and will continue to build up terrestrial energy production (Puchkov, 2015). The geocentric vision of "sustainable energy" development does not allow a significant and long-term extension of mankind's evolution. There is a limit to the production of energy on our planet because of its overheating, and this limit should not exceed a thousandth of the energy received from the Sun. Consequently, the further growth of energy used by mankind is expedient only with the wide development of energy processes outside the Earth. The creation of an industrial-energy base in space (primarily on the Moon) will make it possible to transfer both energy-intensive and environmentally harmful products from the Earth. This is a fairly obvious imperative and the goal of transition to space SD: the exploration of outer space should promote a global transition to SD, and the space activity itself also has to become a sustainable process.

In the near space future, mankind will have to massively ship the production of energy and materials outside the planet, instead of deploying this industry in undeveloped territories, for example, in deserts, the Arctic, the Antarctic or in the oceans and seas. The main reason for the relocation of the energy and some other industries outside the Earth is related to the transition to SD and especially with a number of environmental issues, such as global warming and depletion of the world's fossil fuel and energy resources with the increase of energy consumption. Therefore, the development of any new terrestrial territories, for example, the ocean, is economically inefficient and environmentally impractical. In the case of the development of space bodies, a new anthropogenically-space method and a method of preserving the terrestrial biosphere, as well as the creation of it of the most favorable conditions for the existence of mankind and other forms of life, appear. Therefore, those projects that in the acceptable future can be implemented in space are hardly worthwhile to implement on the planet.

A fundamental conclusion about the need for the future to "split" production into terrestrial, mainly agricultural and space, mainly industrial, between which the products of activity can and will be exchanged has already been made on the basis of an analysis of current trends in the environmentalization of economic and other anthropogenic activities in the context of achieving global sustainability. Agricultural production in the perspective of the transition to SD should fit into the biosphere, using intensively-ecologized methods of economy management (Bazaluk et al., 2020). The strategic perspective of the global-space production split is the most natural and effective one and is understandable in terms of ensuring eco-and geo-security of the civilization's existence (Zhuchenko & Ursul, 1983).

The relocation of the industry, including mining, beyond the planet, is based on its intensive xenobiotic action on the biosphere. However, it will no longer harm the biosphere outside the planet. The relocation of certain enterprises and even industries to space or their further development on the planet will be determined, first of all, by considerations of the optimal achievement of the global-space stability of the "man-society-nature" system.

It is, therefore important to use space objects and their resources in order not to violate international law. This way of development of the space mining industry is not only more in line with modern space international law, but also a further transition to SD in its global and extraterrestrial directions. If the development of scientific trends and industries engaged in exploration activities and mining operations goes along the "merchant path," then its prospects will be very dangerous for the transition of the world community to SD. Getting an opportunity to do business with space resources at a certain stage can even promote these private developments. But in the future, it is fraught with littering of the planet by space resources, which, after use, will become terrestrial waste, and which will significantly impede the achievement of global sustainability.

It has already been noted that the achievements of archaeometallurgy of recent decades add qualitatively new evidence in modern ideas about the development of the Neolithic revolution, make it possible to single out a separate community of miners-metallurgists and put it next to farmers and pastoral communities as an important component of the progress of the Neolithic revolution (Haiko, 2013; Ursul, 2020). Further prospects of mining development will be associated not only with the expansion of underground space, the introduction of new methods of exploration, the use of borehole geotechnologies, the development of deposits on the seabed, and large-capacity deposits. Now we can expect that an equally important role can be played by space mining as an important part of a new, already extraterrestrial revolution in the formation of a new way of socio-natural interaction.

Formation of the Cosmic Way of Socio-Natural Interaction

The development of production in space, especially resource production, is a new radical transformation in the development of all previous material production. Space production is likely to differ from terrestrial production no less than material production from hunting and gathering. The basis for this opinion is that these latter developed on the planet, in fact, in the same natural conditions, differing mainly in the ways and technologies of interaction with the Earth's nature. These methods were endogenous-anthropogenic nature, and space production will develop in fundamentally different natural conditions outside the Earth, and this exogenous factor will significantly affect all production activities.

In our opinion, the removal of products from the planet to a new natural environment will have such a significant impact on the evolution of this main civilizational process that it raises the question of the possible formation of a new way of social and natural interaction. This will be, on the one hand, a continuation of earthly material production, but on the other hand, a completely new process due to the interaction of man with the extraterrestrial environment. A mode of production will begin to take shape, increasingly different from the current "planetary-production" way, which is appropriate to give the name of "production-cosmic" and the main features of which have yet to be identified. However, since humanity will simultaneously continue to inhabit the planet and settle beyond it, the aggregate way of interaction between nature and society will be their mutual earth-space combination (complex).

In the future, as has already been shown, there will be a split of modern terrestrial social production on Earth, mainly agricultural and space, mainly industrial, between which the exchange of products of activity will be carried out (Zhuchenko & Ursul, 1983). The strategic perspective of the earth-space bifurcation of material production is the most natural and effective, understandable from the standpoint of ensuring the ecological safety of the further existence of civilization. After all, only in this bifurcation will open up new opportunities for a significant reduction of anthropogenic pressure on the biosphere, the transition to further comprehensive intensification and sustainable development. This does not mean that we are talking about the "landing" of agricultural production, which is most organically linked to the biosphere. In the future, the space direction of its development is expected, but it will be formed much more difficult and slower than the industrialization of extraterrestrial space.

It is advisable to leave the planet to develop those industries, which are agriculture, ie directly affect the adaptive intensification and increase of efficiency of agriculture, livestock, and neoliberalist, allowing you to more effectively solve the food problem in the long term of mankind's transition to sustainable development. Thus, the consideration of space factors in the evolution of social production shows that, along with the widespread use of space means, earth factors will also be used in a new way, space and earth directions and forms of development and security will be intelligently combined.

The removal of industry, including mining, outside the planet, is primarily associated with its intense xenobiotic impact on the biosphere: after all, outside the planet, it will not harm the biosphere. The relocation of certain enterprises and even industries to space or their further development on the planet will be determined, first of all, by considerations of the optimal achievement of the global space stability of the "man-society-nature" system.

It is important to note that, so far, space activities have been sent to Earth, mostly information about space and about the planet from space. In the resource target, this was mainly the information phase of space exploration, which contributed to the transition to SD. If the Earth, in addition to information, will be delivered to the material and energy resources, such geocosmic activity in its commercial version, will only bring the ecological collapse of the biosphere. Meanwhile, progress on the way to SD is, in principle, focused on the reverse movement-from Earth to space: therefore, the beginning of space exploration and the transition to SD occur approximately in the same historical period, including in human activities new ways and ways of survival of mankind. Wide space exploration by mankind is necessary for the further continuation of progressive evolution in the Universe, the formation of its new, more complex and high levels of stages (Bazaluk, 2016; Ursul, 2019).

Conclusion

A global world should be construed as a state (and process) of civilization and its interaction with nature fulfilled in the global dimension through a transition to sustainable socio-natural development. The perception of a global world through the lens of global sustainability leads to the identification of two stages in such global development.

The first stage is already being implemented in the unsustainable development model when this kind of world is starting to take shape but is fundamentally incapable of attaining the required coherence and security and can even be wiped out as a result of an environmental or any other man-made disaster. This is why the ultimate creation of a global world should be expected at the second stage after securing global sustainability (Ilyin & Ursul, 2019).

The making of a global world is associated with two opposite trends. On the one hand, the realm of social and socio-natural interactions is expanding to the extent of the planet's biosphere. On the other hand, this expansion is obstructed by planet-scale (primarily, biospheric) constraints engendering certain limits and conflicts on the path of further global development.

These conflicts include the essential socio-natural conflict when the Earth's biosphere is increasingly less capable of meeting mankind's soaring needs. This is why it is crucial to ensure that sustainable development is supposed to resolve this conflict, acquires a global dimension, and turns into global development and that the latter turns into SD. Further sustainable development with a clear need leads to space exploration on a large scale using space mining.

Thus, it can be considered that mining beyond the planet might become more actively involved in space activity and can become its most important component and give a new impetus and direction for the development of extraterrestrial spaces. It is possible to talk about such interaction between astronautics and extraterrestrial mining when in a certain sense, they are able to become components of each other in the foreseeable future.

If in the first stage of human space expansion, the "starting base" was the Earth and its resources, then in the foreseeable future, not only the planet, but also celestial bodies, not only their information, but also real-energy resources will be relevant. This is made possible by the predicted development of space mining, which will divide the history of space exploration into two historical stages — before the emergence and development of space mining and the continuation of space activities with the development of mining outside the Earth (although there are other classifications of the stages of space exploration). Thus, space mining will contribute to the sustainable development of space exploration on an extraterrestrial basis, which will open unlimited possibilities for the penetration of mankind into the Universe.

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