Transport factors in the long-term development of the eastern part of the Arctic zone of Russia

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Abstract. The authors consider the importance of the transport factor in the development of new territories and formation and functioning of territorial socio-economic systems in the East of the Arctic zone of Russia. Transport links are primary in the development of socio-economic systems, since mastering of a territory and the formation of the corresponding territorial systems begin with them. The features of the natural resource potential of the East of the Arctic zone of Russia as the basis of its economic activity are highlighted. In this regard, a certain similarity was noted between the regions of the Arctic zone of Russia in their industrial production specialization i.e. mining of non-ferrous and precious metals are present in all regions. The basic functions of all modes of transport for the East of the Arctic zone of Russia are shown. The specific role of transport factors in mastering of natural resources in the Arctic regions is also recognized. To ensure integrated long-term (sustainable) development of the East of the Arctic zone, it is proposed to consider a promising option for the construction of the Arctic Railway from the Anadyr and Beringovsky settlements along the Arctic coast to Tiksi, Norilsk, and Novy Urengoy. The proposed Arctic railway will become a powerful regional factor. On the one hand, it will have a great impact on the development of supporting economic centers on the coast, both existing and new. On the other hand, it will sharply increase the adaptive potential of the population living in this zone. At the same time, effective complementarity of the developing Northern Sea Route by rail can be achieved. All that will become important prerequisites for the long-term development of the Arctic zone of Russian Far East.

1. Introduction
The subjects of the north of the Russian Federation stretching from the northwest border to the extreme northeast of the country enter the Arctic zone of Russia. They are the Murmansk and Arkhangelsk regions, Nenets autonomous region, Republic Komi, Yamal-Nenets autonomous region, Krasnoyarsk region, Republic Sakha (Yakutia), and Chukchi autonomous region. The important feature of these subjects is that their northern borders are washed by the seas of the Arctic Ocean (the Barents, White, Karsky, Laptev, East-Siberian, and Chukchi seas). The southern borders of the Arctic zone reach 62°N. (Cape Rubicon is an extreme southern point of Chukchi autonomous region). The "east" part of the Arctic zone includes the northern areas of Republic Sakha (Yakutia) and the whole territory of Chukchi autonomous region.
In the course of settling and economic development of the Russian part of Arctic regions the favorable economic-geographical factors manifested themselves. They contributed to involving these territories into social and economic development of the country. First of all, it is the unique and richest nature-resource potential of a land and the sea (oil, natural gas, coal, ores of black, nonferrous and precious metals, wood, bio-resources of the seas). It is necessary to distinguish a “coastal-sea” economic-geographical position of all Arctic subjects, which are united by possibilities of the use of the Northern sea Route (NSR). At present, the use of transit possibilities of NSR has a great meaning, since NSR allows us to connect not only Siberia and the Far East with the subjects of the European part of the country, but also the countries of Asian-Pacific region with the European Union.

Thus, it is necessary to consider the presence of negative factors of development of the Arctic territories and water areas: the very difficult, extreme nature-climatic conditions (low temperatures of air, long polar night, ecologically vulnerable tundra and forest-tundra landscapes, and others); a sparsely populated territory; a low level of development of an infrastructure (including transport), and frequently, its absence, etc.; that causes the high cost price of the goods and services produced there; the great remoteness from the production commodity markets in Russia and abroad. Thus, now in the Arctic zone of Russia the most attractive to investors are activities providing manufacture of highly liquid goods, such as oil, liquefied natural gas, and precious metals. The Arctic zone can receive an additional impulse of social-economic development as a result of realization of the investment projects connected with infrastructural arrangement of the territory, including creation of the basic coastal bases along the Northern sea way.

2. Formulation of the problem

As historical experience shows, the discovery of significant and diverse natural resources was the driving force behind the development of many eastern regions and territories. Forest, furs, gold, land, fish were at the first stages of the development, and coal, metals, diamonds, oil, gas, chemical raw materials and others at the next stages. To ensure their exploitation and use in undeveloped territories, enterprises, infrastructure, and settlements were built. The “Northern” delivery of large volumes of construction materials, various technological equipment, consumer goods and foodstuffs for local population required the organization of a reliable transport system connecting these territories with developed regions. Subsequently, this transport as a rule began to export large volumes of extracted resources and raw materials from the mastered territories to other areas for processing.

A number of foremost works are devoted to the study and assessment of the role of various modes of transport in the development of eastern regions [1-4]. Interesting works devoted to the importance of transport in the development of the Arctic zone of Russia have been performed recently [5-7]. But insufficient attention in these works was paid to the analysis of the complex content of transport factors and the disclosure of their various functions, important not only in the mastering of natural resources, but also in the adaptation of local population to Arctic conditions. The importance of building a railway in the Northern regions was noted by Andrianov [7]. However, the Transpolar Railway proposed by him runs much south of the coast of the Arctic Ocean.

3. Materials and methods

Official policy documents on the development of the Arctic regions, statistical and cartographic materials, and scientific publications were the source materials for the study. Comparative geographical statistical and cartographic methods were used. The authors applied a systematic approach in the analysis of the processes of development of territories.

4. The main results

Transport factors are binding in the combination of nature-resource factors with economy and the population of the economic centers in the Arctic zone of the Far East (AZFE. Now about 1,100 deposits and displays of mineral resources are known there. The area of the Arctic territory of the Far
East is 1,318 thousand km². The share of mineral-resource deposits by our estimations makes up about 11% from the Far East level. The degree of a geological level of scrutiny of these territories is not high even by the Far East measures. Therefore, the density of deposits makes up about 1,2 on 1,000 km². For the comparison, the given indicator across the Far East makes up 1,65, and across Russia - 2,2. A variety of kinds of resources is rather great on a land. Its basis is composed by 10 kinds of firm mineral raw materials (Fig. 1, table 1).
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The prevailing share of precious metals in the structure of deposits is the peculiarity of the Far East Arctic zone. In this plan it is worthy to note Bilibinsky region of Chukotka where about 300 deposits have been found that makes up 40 % from the deposits of precious metals of the Arctic zone of the Far East. Tin deposits take the second place. On Chukotka in Chaunsky region about 60 deposits have been revealed. Thus, the third of tin deposits of ZAFE locate in this territory (table 2).

### Table 2 Number of deposits and its territorial structure in the Arctic zone of the Far East, [8, 9].

| Territory | Area, Thousand km² | Number of deposits | Density per 1,000 km² | Tin | Mercury | Tungsten | Diamonds | Copper | Lead | Uranium | Hydrocarbons | Construction |
|-----------|--------------------|--------------------|----------------------|-----|---------|----------|----------|--------|------|---------|--------------|--------------|
| Chukotka  | 713.4              | 859                | 1.2                  | 100 | 100     | 100      | 100      | 100    | 100  | 100     | 100          | 100          |
| Bilibinsky| 174.7              | 313                | 1.79                 | 47.8| 1.5     | 18.2     | -        | -      | 80   | -       | -            | 11.3         |
| Anadyrsky | 287.9              | 157                | 0.54                 | 19.7| 0.8     | 45.5     | -        | -      | 20   | -       | -            | 95.5         |
| Yiultinsky| 134.6              | 195                | 1.45                 | 16  | 2.5     | 77.8     | -        | -      | 100  | 50      | 4.5          | 52.8         |
| Providensky| 27.4              | 9                  | 0.33                 | 1   | 1.5     | -        | -        | -      | -    | 50      | -            | -            |
| Chaunsky  | 58.7               | 180                | 3.1                  | 15.5| 52      | 27.3     | 11.1     | -      | -    | -       | 20.8         | -            |
| Chukotsky | 30.7               | 5                  | 0.16                 | -   | 1.5     | 11.1     | -        | -      | -    | -       | 3.8          | -            |
| Yakutia   | 605                | 256                | 0.42                 | 100 | 100     | 100      | 100      | 100    | 100  | 100     | 100          | 100          |
| Allaikhovsky| 107.3             | 14                 | 0.13                 | 2.8 | 18.2    | -        | -        | -      | -    | -       | -            | -            |
| Anabarsky | 55.6               | 35                 | 0.63                 | -   | -       | 86.4     | -        | -      | 57.1 | 55.6    | -            | -            |
| Bulunsky  | 235.1              | 29                 | 0.12                 | 13.9| -       | 13.6     | -        | -      | 35.8 | 11.1    | -            | -            |
| Ust-Yansky| 120.3              | 165                | 1.37                 | 75  | 81.8    | 100      | -        | 100    | -    | 7.1     | 22.2         | -            |
| Nizhneolomsky| 86.8              | 13                 | 0.15                 | 8.3 | -       | -        | -        | -      | -    | -       | 11.1         | -            |

By the variety of deposits of mineral resources the first place in AZFE belongs to Iultinsky region of Chukotka where 8 of 10 principal kinds of mineral raw materials locate. Iultinsky region has a great meaning for a regional mineral-raw base. This can be confirmed by such kinds of minerals as common minerals, uranium, and tungsten; over 50 % of these minerals are concentrated in this region, and lead and tin make up 1/3 deposits of AZFE. In Republic Sakha, Ust-Yansky region takes the leading place in a specific variety of deposits. In this region 6 of 10 principal kinds of mineral raw materials locate. The feature of this region is that there are 2/3 deposits of lead and 1/4 deposits of mercury. Among spatially-structural features of a mineral-raw-material base at the level of municipal unions it is possible to note some of them. The regions of Chukotka: Anadyrsky on which over 70 % of deposits of hydro-carbonic raw materials fall, Bilibinsky on which about 80 % of deposits of copper and 40 % of gold and silver fall, Chaunsky where there are 40 % from the regional number of tin containing deposits. On the other hand, one can allocate a group of municipal unions with a poor specific variety of deposits. For example, Providensky region, where about 50 % of the regional number of deposits of uranium [10] is concentrated at the same time, can be singled out. The poorest variety of mineral deposits can be noted in Providensky region of Chukotka, and also in the Nizhneolomsky and Allaikhovsky uluses of Republic Sakha.

In the structure of the total added cost of all subjects of the Russian part of Arctic regions, such a kind of activity as mining operations (oil extraction, natural gas, coal, ores of nonferrous and precious...
metals) prevails. As a whole, in the Russian Federation. Its share in the total added cost has made up 10.9% in Nenets joint-stock company it reached 74.5%; in Yamal-Nenets joint-stock company - 54.5; in Republic Sakha (Yakutia) - 51.6%; and in Chukchi joint-stock company - 50.1. At the same time all subjects of the Russian part of Arctic regions (except Krasnoyarsk region) are characterized by weak development of processing manufactures and a social and industrial infrastructure.

In the structure of economy of the subjects entering the "east" part of the Russian sector of Arctic regions it is necessary to mark the leader of such a kind of economic activities as extraction of mineral natural - resources (extraction of ores of nonferrous, precious metals, and diamonds) - in Republic Sakha (Yakutia) and in Chukchi Autonomous region. Besides, fuel is extracted in the following subjects: in Republic Sakha (Yakutia) - coal, oil, and natural gas; in Chukchi autonomous region - coal. Export of coal from the deposits of Republic Sakha (Yakutia) is an important element of international trade of Russia with the countries of Asian-Pacific region. It is possible to note similarity of the structure of economy of these subjects: all of them specialize in extraction of ores of precious metals; the coal industry plays an important role in maintenance of requirements for fuel of local thermal power stations. Distinctions in the structure of economy of subjects are connected, first of all, with the level of development of the territory, the size of the achieved industrial and demographic potentials. Thus, the Republic Sakha (Yakutia) undoubtedly has more differentiated structure of economy, high social and economic potential.

Such features of branch structure of the subjects of the Russian part of Arctic regions have developed as a result of the influence of a set of social-economic and economic-geographical factors (a rich nature-resource potential, an Arctic economic-geographical position, a heavy environment for population and housekeeping life, weak development, and frequently, full absence of an infrastructure, etc.).

The role and importance of transport factors in the development of new territories can be more fully revealed through the analysis of the functions of transport links in the formation and functioning of territorial socio-economic systems [11]. In the development of the latter, transport links are primary, since the development of the territory and the formation of the corresponding territorial systems begin with them. In this case, transport performs (and should perform) the following functions: transportation of materials and equipment for the construction and formation of all material links of territorial systems; transportation of fuel and energy resources for their formation and functioning, transportation (exports) of finished products, including extracted natural resources and raw materials to other areas; transportation of consumer goods for the population, including food, and finally transportation of people themselves, population groups like short-distance, pendulum (to work, to school, etc.) and long-distance and inter-district trips.

All these connecting functions of transport are extremely important for the Arctic regions. Sustainable transport links here and their general reliability strengthen the adaptive capabilities of the population and increase its survival. If people are sure that they can leave the district of residence and get to any other region of the country at any time, they will not seek to change his place of residence.

The special role of transport factors is in mastering of natural resources in the Arctic regions. Firstly, the significance of reliable transport to export of extracted raw materials and natural resources to other and more southern areas sharply increases. Secondly, due to the high costs of all natural resource extraction processes, efficient transportation is advisable only for high-value goods and their relatively smaller volumes.

Currently, the transport system in the Arctic regions of Russia consists of several types of transport. The main one is maritime transport in the form of separate links of the Northern Sea Route. These links provide ties between individual coastal centers as well as with European centers, Murmansk or Arkhangelsk, and in the Pacific up to Vladivostok. There are only six seaports in the Arctic zone of the Far East (table 3). All of them are small - with a throughput capacity of cargo terminals of up to 650 - 900 thousand tons per year. Such seaports as Pevek and Tiksi, located on the shores of the seas of the Arctic Ocean and strategically important for
ensuring national security, servicing the Northern Sea Route and organizing economic activity on the Arctic coast, have the capacity of their terminals only within 70-330 thousand tons of cargo per year.

Shallow waters of nearly all sea ports, limiting the maintenance of modern vessels with large dimensions, is a common problem in the development of maritime transport in the Arctic zone of the Far East. As the experience of dynamically developing neighboring countries shows, a solution to this problem may be through dredging in the most promising seaports. According to our estimates and by assessments of a number of colleagues involved in the development of the Arctic zone of the Far East, the ports of Pevek and Tiksi should become the priority ones for dredging. Pevek sea port, after deployment of the ‘Akademik Lomonosov’ floating nuclear power plant in it, “automatically” becomes a center of economic attraction. The Port of Tiksi, located at the mouth of the largest and navigable Lena River between the Northern Sea Route and the internal regions of Yakutia, is also “predetermined” to perform even larger-scale functions of organizing economic and social life (as well as the functions of water, air transport, national, energy security, and “northern delivery”) in this vast space due to its geographical location.

Table 3. Main characteristics of the Arctic seaports of the Far East

| Seaport       | The area (water area + territory, km²) | Cargo terminal throughput (thousand tons per year) | Vessel dimensions (length / width / submersion), m | Number of berths(length) | Number of stevedores |
|---------------|---------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------|----------------------|
| Pevek         | 8,9 + 0,19                           | 330                                              | 172,2 / 24,6 / 9                                  | 3 (500 m.)               | 1                    |
| Tiksi         | 96,78 + 0,07                         | 67                                               | 129,5 / 15,8 / 3,9                                | 2 (315,0 m.)             | 1                    |
| Anadyr        | 45,33 + 0,12                         | 900                                              | 177 / 25 / 7                                     | 6 (686 m.)               | 1                    |
| Beringovsky   | 47,07 + 0,22                         | 646                                              | 34 / 7 / 2                                       | 4 (269 m.)               | 1                    |
| Provideniya   | 13,02 + 12,7                         | 345,4                                            | 200 / 24 / 10                                    | 3 (321,4 m.)             | 2                    |
| Egvekinot     | 5,75 + 0,07                          | 350                                              | 177 / 25 / 12                                    | 3 (565,3 m.)             | 1                    |

The ports of Pevek and Tiksi should be considered as promising “supportive” multi-functional points for the development of the Eastern sector of the Arctic, which along with transport, energy functions and ensuring national security, should also perform the functions of organizing the economic and social life of the population in this extremely demographically “sparse” space of the North East of the country.

An important role in the transport system of the North is played by river transport along the Ob, Yenisei and Lena rivers. The cargo flows along these links are developed in the framework of so-called “northern delivery” (seasonal, mainly spring-summer and summer-autumn transportation of goods from the southern regions of Siberia and the Far East to the northern and Arctic regions to ensure their normal functioning during the winter periods). In the future, these links of river transport can also contribute to the development of natural resource potential within the territories adjacent to these rivers. In this case, new types of river vessels with low submersion can be used. In places of loading of raw materials on them, transport and economic points and nodes will be formed.

Air transport provides the fastest communication between the main settlements of the Arctic North, both among themselves and with the "mainland". Passenger transportation and transportation of relatively small volumes of perishable or high-value cargo is the most effective direction for the development of air transport.

To ensure the comprehensive long-term (sustainable) development of the Arctic zone of the Far East, we propose to consider the option of the Arctic Railway from Anadyr and Beringovsky settlements along the Arctic coast to Tiksi, Norilsk, and Novy Urengoy. Such a railway, firstly, would connect both supportive development zones and basic supportive centers, large and small transport hubs with reliable transport links, and secondly, would ensure effective interaction in latitudinal deliveries with
the Northern Sea Route. At the same time, it is understood that there is already the railway to the west from Novy Urengoy, including the exit to the Trans-Siberian Railway in the Tyumen region.

5. Conclusion
Transport factors played a very large role at all stages of mastering and development of the Arctic coastal regions. In the early stages, maritime transport played a specific role. The latter has great prospects for the future as well. However, only the railway transport can provide such an important transport function as an auxiliary safety net for the North. The proposed Arctic railway will become a powerful regional factor. On the one hand, it will have a great impact on the development of supportive economic centers on the coast, both existing and new. On the other hand, it will sharply increase the adaptive potential of the population living in this zone. At the same time, effective complementarity of the emerging Northern Sea Route by rail can be achieved. All these will become important prerequisites for the long-term development of the Arctic zone.

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