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# FORMATION AND DEVELOPMENT OF THEORETICAL PRINCIPLES FOR MINERAL RESOURCES LOGISTICS

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Market transformations in Russia became foundations for formation and development of a new scientific and practical field in economics – logistics. Out of more than 30 existing definitions of logistics the authors according to their opinion have chosen the most appropriate. Logistics of mineral resources should be attributed to production (industrial) logistics. It is a proven fact that processes of supply chain management in mining industry and its infrastructure in the framework of mineral resources chain have some fundamental distinctions. Importance of material resources recycling in theory and practice of mineral resources logistics has been highlighted. Special features of merchandise assortment and classifications in the mining industry have been examined in conjunction with substantial contents of material flow. Special consideration has been given to relevant issues in the field of price formation for mining produce, in the view of specific relations between its costs and logistic procurement of the industry. Moreover, questions of inventory control in the mining industry, activity of commodity exchanges, management of mining logistics system have been addressed.

***Key words*:** logistics, mining industry, management of mineral resources flow, theory and methodology of mineral resources logistics

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**Introduction.** Market transformations in the 90$^{s}$ years of 20$^{th}$ century have brought to life a new scientific and practical field in economics – logistics.

Up till now there are more than 30 definitions of logistics. All the definitions are correct, as they fully reflect complexity of processes and events in modern economics. Nevertheless, all these definitions converge to the fact that logistics is a science of managing economic flow in the spheres of production and distribution. Furthermore, logistics has developed elaborate tools aimed at providing competitiveness of all enterprises – manufacturing, commercial and service ones.

A renowned source recommends to use the following definition: «Logistics is a science of managing material flow, related information, finance and services in the economic system to reach stated objectives with optimal costs » [4, p.3].

Production logistics can be regarded as a synthesis of general logistic theory and relevant economy branch. Mineral resources logistics can also be attributed to production (industrial) logistics. It should be acknowledged that mineral resources sector of economics clearly underestimates significance of logistics, which is indicated by the lack of scientific publications and educational materials in this field [11]. Nevertheless, specialists in mining economy and management without understanding of mineral resources logistics cannot be qualified as professionals by the latest world standards.

**Methodology.** Mineral resources logistics objectively exists, and it can be characterized by some fundamental distinctions, that have to be taken into account in the process of production and economic activity of mining enterprises to achieve required results [10].

The basics of methodology to start a new scientific field «Mineral resources logistics» can be formulated as follows:

1) specifics of the term «resources» in the meaning of subsoil resources and differences from traditional inventory resources in logistics of enterprises;

2) specifics of natural resources distribution in the subsoil and requirements to take this distribution into account in the course of development of mining enterprise's logistics;

3) fundamental differences in the methodology of norm setting for subsoil natural resources;

4) specifics of transport and storing of extracted natural resources;

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5) ability to exhaust subsoil resources, their non-renewable character and spatial relocation of mining development centers under the influence of natural depletion of deposits;

6) special role of mineral resources import for international economy as a whole and national economy in particular;

7) specifics of inter-sectoral and cross-functional connections in logistical system of mineral resources complex;

8) need to take into consideration environmental requirements in mineral resources logistics;

9) specific «legal environment», defining the framework of general development as well as logistical activity of the mining enterprises.

It is necessary to examine some theoretical principles of mineral resources logistics.

Logistical flow processes are embodied in supply chains. It is generally recognized that in management there is a sub-field «Logistics and management of supply chains» [1]. Thus, it is supply chains that are the first and foremost object of logistical management [6].

According to management theory, only systems can be controlled. Hence, before establishing control, a system has to be created. A multitude of separate enterprises is not yet a system, it becomes one only after each enterprise of this multitude implements logistical concepts [2].

Supply chain has no direct operator in a sense of an organized structure standing behind all other elements of the chain. However, informally such an operator exists: this role belongs to the personnel of logistical management of every chain element. A necessary functioning condition of such informal operator is personnel using logistical concepts to the greatest extent possible.

An instrument of considered virtual operator consists of the following logistical concepts:

1) SCM – Supply chain management;

2) MRP – Materials resource planning;

3) JiT – Just in time;

4) DRP – Distribution requirement planning;

5) ECR – Effective customer response;

6) VMI – Vender managed inventory [14].

**Results and discussions.** All abovementioned concepts are characteristic of all members of a supply chain, both manufacturers and sellers. With this being said, the key role in developing a collective and coordinated action is given to SCM concept. In this regard it is enough to mention its module «Customer relationship management», because every subsequent element of the chain is a customer interested in goods or services.

According to logistics theory, SCM concept can be considered «integrated logistics», so that this concept defines unity of efforts of all supply chain members.

Supply chain management is an integration of eight processes [9]:

1) customer relationship management;

2) customer service;

3) demand management;

4) order fulfillment;

5) manufacturing flow management;

6) procurement management;

7) product development and commercialization;

8) return flow management.

From the viewpoint of logistical concepts the simplest supply chain is examined. It only contains three elements: supplier – manufacturer (focal enterprise) – customer. For mineral resources logistics a starting element will be «Nature», hence the whole supply chain can be obtained, which comprises 10 elements:

1) nature (subsoil) – mineral deposit under development;

2) extraction – mining enterprise;

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3) processing – bringing to industrial level (to the level of raw product);
4) direct materials manufacture;
5) wholesaler – direct materials sales;
6) manufacturer – focal enterprise;
7) wholesaler – finished product sales;
8) customer –finished product consumer;
9) retailer;
10) ultimate consumer – retail customer.

Of all abovementioned elements only the first three are directly related to mineral resources logistics: nature – extraction – processing, and «the output» of this chain will be a raw product as initial material resource for further movement along logistical flow to the ultimate consumption [3].

Schematically these elements of the supply chain can be presented in a graph (Fig.1).

In mineral resources logistics special attention should be paid to the initial – natural – element of the chain. Thus consider traditional classification of mineral resources [8]:

1) indentified/known;
2) demonstated: measured/proved; undiscovered/probable;
3) reserves;
4) economic;
5) marginal;
6) hypothetical.

The first element as an object of mineral resources logistics contains a full range of geologic explorations.

On the whole presented classification of mineral resources points to their scarcity, which explains why the imperative of mineral resources logistics is a search for alternatives.

An important role in mineral resources logistics is played by recycling of material resources. In this context an alternative is the use of secondary material resources – industrial and consumption wastes (ferrous and non-ferrous scrap metal, waste paper, spent oils etc.). Waste, as opposed to losses, maintain their material substance and thus retain residual utility [15]. Recycling in the form of a return material flow is included in SCM concept. Technical and economical justification of waste being used as a raw material should necessarily include an environmental assessment of the process efficiency. The latter requirement predetermines the need of mainstream use of secondary material resources in order to conserve the primary ones [13].

From the viewpoint of objects of management and flow elements, material resources in logistics are divided into following groups:

I. Raw materials – material resources, directly extracted from their natural state by a processing technology.

II. Direct materials – material resources, obtained from raw materials with a complex step-wise technology: they constitute the main material substance of the finished product.

III. Indirect materials – material resources, supporting the process of manufacturing a finished product or added to it.

IV. Semi-finished products.

V. Parts and components.

VI. Tools and inventory.

VII. Fuel and energy sources.

The flow of listed material resources is subject to economic and commercial controlling action. Such actions include: taxation system, customs formalities and payments, requirements of supervising authorities, inspections etc.

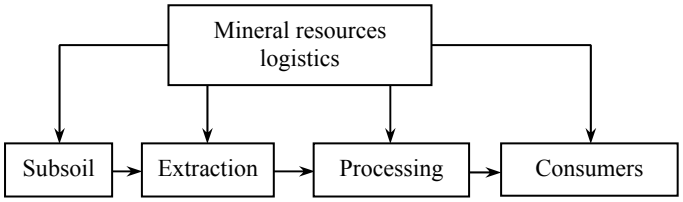


Fig.1. Elements of mineral resources chain

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On the average, duration of one cycle of material resources (objects of production) in the mining industry varies between 35 and 45 days. Number of cycles per year is from 8 to 12. Average duration of one cycle of means of production is 16-20 years. For mining equipment it varies between 1-2 years (e.g., for rock drills and other equipment) and 25 years and more (for large excavators).

Functions of procurement and distributive logistics are a premise, condition and factor of simple and extended reproduction of fixed and working assets of the mining enterprise. In this context procurement and distributive functions should be subordinate to a single manager.

For many branches of a processing industry the share of materials in total costs reaches 50 % and more, but for industrial costs of mining enterprises this indicator averages 25-30 %. At the same time production process at such enterprises is associated with very high amortization costs for fixed assets. Notably, specialist training is also quite costly, which is explained by a necessity to use expensive equipment in the educational process.

In the industrial process mining enterprises use 25-30 thousand items of merchandise, produced by almost all manufacturing sectors. For instance, mining industry requires following supplies: ferrous metals and metal goods, different types of iron and other metals, rolled ferrous metal products and their downstream products, pipes, fittings, bolts, screws, nails, wire, nets, electrodes etc.; non-ferrous metals and their rolled products, refractory products, forest and construction materials, wood products – plywood, tiles, wood veneer etc.; sanitary wares; iron-mongery; paper and carton; forest chemicals – turpentine, rosin, tars, cellulose etc.; non-metallic insulators – graphite, quartz sand etc.; technical glassware; radio technical devices, paints, lacquers and other chemical products; protective clothing, personal protective equipment, fabrics, ropes, cleaning agents, other supporting materials; instruments, bearings, gas-plasma apparatus; oil products, solid fuels, gas; electrical and electroinsulating products; cables; piping valves; equipment according to industrial classifications etc.

Besides traditional functions, mining logistics is also involved in incorporating services of other economic entities – enterprises and organization – in the process of its industrial and commercial activity.

One of the key complex logistical activities is price formation [7, 8].

It can be stated that pricing plays a central role in mineral resources logistics, as it determines the flow of goods across the whole supply chain, as well as the final price of the product. Considered pricing takes into account following specifics:

– natural resource rent;
– land prices;
– environmental renovations;
– environmental measures in the course of extraction and processing of mineral resources;
– increase in the cost of work due to difficult working conditions (continental shelf, Arctic shore, tundra etc.);
– additional labor costs, including social expenses;
– use of specific and, as a rule, expensive equipment;
– accelerated amortization etc.

On the whole, logistics can be distilled down to the following basic logistical processes [5]:

1) purchasing (procurement);
2) sales (marketing, distribution);
3) relocation (transportation);
4) inventory management (stocking).

Each of this basic processes of mineral resources logistics has its own distinctions.

Extracting industry has two major groups of material resources needed for material and technical procurement:

1) material resources for maintenance, repair and operational needs of equipment, including petroleum, oil and lubricants;

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2) chemical products in the form of reagents and catalysts for processing and preparation of raw materials as a finished product of the industry.

From the viewpoint of logistics, procurement is a central process, as it determines effectiveness of economic activity. Hence logistics has developed a system of procurement optimization using around 15-20 criteria.

The possibility and the need to optimize procurement are explained by the fact that in market economy supply exceeds demand and therefore consumers have more freedom when choosing a supplier. Situation in the mineral resources sector is totally different: here choice options are very limited, and the game is played by different rules.

A special role in procurement logistics of a mining enterprise is played by commodity exchanges that in their essence operate as organizers of respective markets of mineral resources. Commodity exchanges offer commercial information to the interested parties, including trading participants. They «balance out» total demand and total supply for respective resources, organize their consumption and distribution, the process of goods exchange [12].

Logistical competences include setting of norms for material and energy intensity. Material consumption is characterized by relatively low material costs, which in its own turn leads to a high level of added value, which accumulates as the material flow moves along the chain supply. Added value is a difference between the product price, profit included, and material costs. Despite the fact that processing industry is quite energy-intensive, the issue of energy consumption requires further development.

Sales in mineral resources logistics are to a great extent predetermined by technologic factors and in the elements nature – extraction – raw product production – they have a specific character, therefore they are not subject to market influence. In other words, these elements create their own sub-system in the form of an independent complex of raw material production in a logistical sense. That is why there is a need to understand the process of sales in mineral resources logistics in a scientific sense.

One of scientific and practical problems of mineral resources logistics is establishing cause-effect relationship between raw materials and prices of finished and semi-finished products.

In this context logistics calls for «deep» and complex processing of initial – natural – mineral resources with a wide «output» variety of raw products, especially for export purposes. This approach allows to overcome resource curse of economy, as the results of processing become, in a logistical sense, finished products.

In the system of logistical management it is essential to investigate and define the level of research intensity of mineral resource products as one of important factors of managing the goods flow.

Another distinctive feature of mineral resources logistics is its «inventory». The term itself, as well as logistics on the whole, is universal. It means that any enterprise – manufacturing, trading or service one – possesses material inventory. It is characteristic of economic activity of any entity regardless of its specializations. Moreover, optimal size of the inventory and its rational management can to a great extent determine commercial success of the enterprise. One way or another, inventory is a part of every logistical chain and channel of goods flow.

In logistics, inventory control is regarded as a central activity, because it constitutes a very important application area for logistical management, as inventory accumulates great masses of material and financial resources of separate enterprises and national economy as a whole. That is why governmental statistic offices regularly calculate inventory intensity of gross domestic product.

*Inventory* is a defined mass of material resources: means of production and articles of consumption, stored either in the production or in the distribution field and facilitating a continuous process of material goods reproduction.

Inventory possesses not only universal, but also objective characteristics. From the viewpoint of economic theory, inventory is generated when the production cycle does not match distribution cycle, hence the main reason of objectiveness of material inventory.

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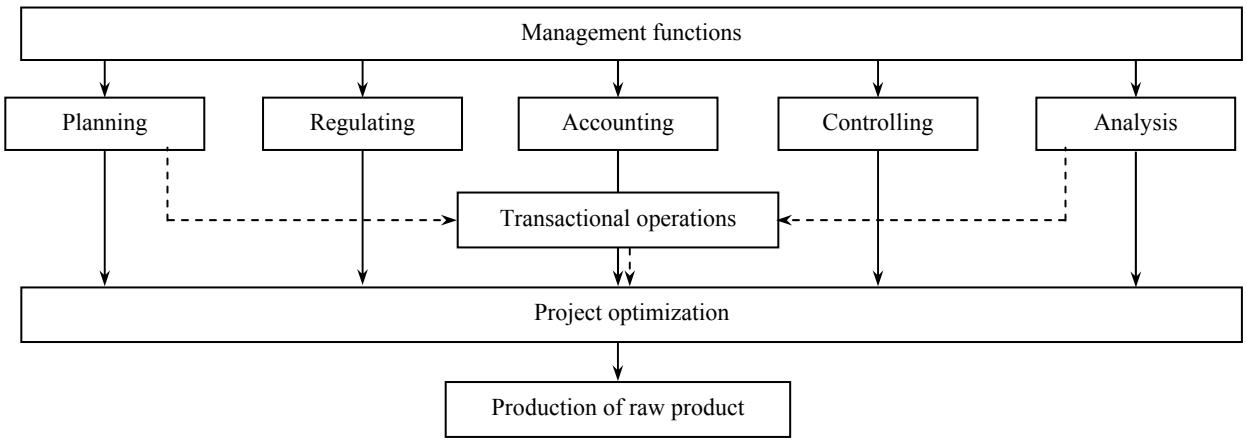



Fig.2. Management functions in mineral resources logistics

Immobilization is the factor that makes logistical management control the inventory and to keep it at the optimal level. Here one should also add the costs associated with generation and storing of the inventory.

Some adjustments have to be made for the inventory of mineral resources. First of all, this inventory is characterized by a low immobilization due to the cost of its extraction and initial processing. It means that the size of mineral resources inventory is practically unlimited. On the other hand, storing of such inventory requires certain expenses: land lease, storage of extracted raw materials etc. Considerations must also be given to other factors of microeconomic nature. Thus an important issue arises: whether logistics should develop methods to define the optimal level of mineral resources inventory.

Material resources stored as mineral resources inventory are not subject to obsolescence – provided the right treatment, their quality does not deteriorate. Furthermore, it can be stated that in such inventory occurs the process of hoarding. This quality of considered inventory can be used as a security for bank loans.

Moreover, mineral resources can also stay in the natural state described by a widely used term «mineral reserves». In this state they can stay until called for, taking into account macroeconomic factors or market conditions.

Logistics operates the value of inventory intensity of production or distribution – similarly this value has to be defined and norms of inventory intensity calculated for extraction and production of raw materials.

Calculation of the demand for material resources is incorporated in one of the modules of MRP concept. A precise and reliable estimation of the demand is a key factor of procurement optimizations, as it serves as a basis for calculating financial resources for purchasing required materials.

As it was mentioned earlier, logistics is the main tool to attain competitiveness and an instrument of resource conservation. Therefore, the essence, directions and effectiveness of resource saving have to be identified for mineral resource complex. Besides, logistics recommends to develop benchmarking – a standard of competitiveness and resource conservation using cutting-edge international experience. This standard can be used as a reference point in the course of economic activity of mineral resources complex.

Logistical management, or logistical system of control, provides the following functions: planning, relating, accounting, controlling and analysis. In mineral resources logistics they acquire practical meaning defined by specifics of the controlled system: mineral resource flows in the economic space. Apart from that, indicated management functions are subject to adequate types of support: scientific, informational, technical, organizational, labor, law.

The fact that planning precedes the actual logistical process of the flow movement permits to regard this function as a project of the whole managing process (Fig.2).

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So, mineral resources logistics pursues the following objectives:

– development of a high level qualification and professionalism of managers and experts in the mining industry;

– wide application of quantitative methods in the economic activity of mineral resources enterprises;

– formulation of the best – optimal – decisions in mineral resources complex;

– practical implementation of integrated control over the entire supply chain in the system of logistical management;

– monitoring of material costs and resource-saving activities;

– achievement of desired compatibility in domestic and foreign markets.

General mineral resources logistics can be divided into separate sector logistics, e.g.: oil & gas logistics, logistics of metallurgy, logistics of precious metals, non-metal logistics etc. Such differentiation can be driven by the amount of accumulated knowledge in general logistics and demands of cross-industrial specialization.

Great significance of mineral resources logistics is explained by the fact that the processes it looks into are a source of all material flows, which serves as an impulse intensifying goods exchanges in the economic space.

As a practical sphere, mineral resources logistics interacts with international organizations aimed at coordination of extracting industry and international raw materials trade. Indicated organizations include: OPEC (Organization of Petroleum Exporting Countries), CIPEC (Intergovernmental Council of Copper Exporting Countries), IBA (International Bauxite Association), AIEC (Association of Iron-Ore Exporting Countries), OTEC (Organization of Tungsten Exporting Countries) etc.

These organizations play a crucial logistical role – define main parameters of international flow of goods or global mineral resources and material flows.

## Conclusions

1. Scientific publications and educational materials in the field of mining underestimate the role and significance of logistics, there is practically no publications on mineral resources logistics.

2. New research field «mineral resources logistics» is founded on basic methodological principles.

3. Mineral resources logistics is characterized by fundamental distinctions that have to be considered in economic activity of the extracting companies.

4. Mineral resources logistics includes first three elements of the supply chain: nature – extraction – processing, and further research and scientific development should focus in this direction.

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