TECHNOLOGICAL STRUCTURES OF MARINE DRESSING COMPLEX FOR THE EXPLOITATION OF SOLID MINERAL RAW MATERIALS OF THE CONTINENTAL SHELF DEPOSITS

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CADASTRE OF MINERAL RESOURCES

Some initial data from the Cadastre of mineral resources about Rucharskoye titanium-magnetite deposit (Iturup island, Sakhalin Oblast).

The Cadastre structure provides for a differentiation of indices, parameters and calculations as well as their division into some classes, characterized not only by geological and mineralogical as well as mining technical features of ore and/or rock composition of a deposit or an ore province, but other information which allows for carrying out an optimal design of both technological structures, mining, concentrating and transporting models and feasibility study of offshore dressing complexes in the future.

It is necessary to obtain the following information about each deposit:

- mining and geological characteristics (total volume of explored reserves and predicted amounts of mineral resources, reserves of metal-containing components at different depths and at the surface, geometry of ore-bearing placer bodies, physico-mechanical features of ore-bearing sands, host rocks, etc.);
- hydro-meteorological conditions, hydro-aerodynamic placer's mode of occurrence, dynamics of the bottom sediment transportation, characteristics of storms, sea level changes, etc.;
- geographic, technical and economic, socio-ecologic characteristics of the placer areas;
- means for underwater mining of solid minerals;
- results of patented investigation in the sphere of technical means thereof, as well as mining and concentrating technologies and complex study of mineral raw materials, technological parameters of placers and technical characteristics (preliminarily) adopted for the development of optional patterns of mining technologies and techniques.

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Cadastre

№	Initial data and parameters (existing and adopted) for developing technological structures of offshore dressing complexes	Rucharskoye (and Reidovskoye) deposits
	1. Mining and geological characteristics	
1	Brief information about deposit/placer genesis	Sediment of modern beach, coastal and eolian sands
2	Total volume of explored reserves and probable/expected amounts of productive sands of titanium-magnetite placers $B+C_1+C_2$ (at the surface), million mt	48.8 200-300
3	Reserves of metal-containing components at the surface, million mt on the shelf, million mt up to 20 m deep, million mt up to 50 m deep, million mt	 9.0-10.0 25.0-30.0 15.0-18.0 10.0-12.0
4	Output of concentrate, % at the surface, % on the shelf, %	11.7-54.0 15.0-20.0 10.0-15.0
5	Geometry of ore-bearing placer bodies: · total length of deposit, km · total length of placer, km · width of ore-bearing sands at the surface, m · thickness of productive ore-bearing sand stratum: max. (surface/shelf), m min. (surface/shelf), m av. (surface/shelf), m · total shelf area, km^2 · configuration of ore-bearing sand placer in plan · stratigraphy of ore-bearing sand thickness and stripping rocks in section along the length of axis	 15.5 28.0 250-260/2,000-3,000 25.0/4.0-6.0 1.0/0.5 6.7-12.3/2.0-3.0 95.0 Stretching, lense-shaped deposit (placer) Fine-grained sands with small amounts of pebbles and pumice fragments
6	....	
7	....	
	2. Hydro-meteorological conditions	
1	Nature of waves (sea-level)	Daily tides of 1.2 – 1.5 m
2	Ice parameters: length of ice period, ice drifting period	48-86 days of ice conditions (January – March), cleaning from ice in the second third of April, ice formation from 1 to 30 days (January – February), ice breaking from 1 to 15 days (April – early May)
	Note: More detailed initial data about Rucharskoye titanium-magnetite deposit is not advised due to limited amount of published information.	

PERSPECTIVES AND PROBLEMS OF UNDERWATER EXPLOITATION OF SOLID MINERAL RAW MATERIALS ON THE CONTINENTAL SHELF DEPOSITS

The world practice of underwater extraction of solid mineral raw materials from coastal/offshore deposits demonstrates the following advantages compared to mining exploration onshore:

- production expenses for preparatory exploitations, stripping and mining exploitations, in particular for drifting sectional trenches, are considerably reduced;
- demand for expensive transport/communications, pits and crushing equipment is excluded;
- expenses for exploitation and storage of rocks, including wastes of concentrating products are sharply reduced;
- necessity of alienation of land suitable for agricultural use, as well as expenses for reclamation of lands, damaged by mining, are excluded.

Large reserves of solid mineral resources on the shelf and offshore in the Far-Eastern seas were revealed by geological works, carried out in the 60's and 70's of the last century. So, the richest resources of ilmenite, titanium-magnetite, magnetite, zirconium, vanadium and other mineral raw materials are on the shelf of the Far-Eastern seas. According to various estimations, the expected reserves make up from 180 to 220 million mt of titanium-magnetite ore raw materials, prognostication of additional reserves equals 700 - 800 mt. Main provinces are located in Iturup island, the Kamchatsky peninsula, the western coast of the Tatar straight and in Primorsk Region as well. According to available information from the Cadastre, the reserves of mineral raw materials are found in sands of the coastal part of Rucharsky (South-Kuril) deposit. It is possible to obtain concentrated products of five-oxide vanadium equaling 42,000 mt from these mineral raw materials.

The volume of ilmenite and titanium-magnetite sands in Protochnoye (Khasan) deposit make up as follows: ilmenite - 2.3 million mt, sfene and zirconium - 1.0 million mt, magnetite - 1.0 million mt (according to licensing data provided by Primorsky Geological Committee).

In spite of sharply increased demand for products of titanium-magnetite raw materials on the Russian domestic market (after dissolution of the former USSR deposits of titanium-magnetite and ilmenite raw materials as sources for metallurgy became located abroad), till now the deposits located on the continental shelf of Russian Far-Eastern seas have not been developed yet.

It is impossible to use in Russia most of ways and kinds of domestic and foreign equipment under strict ecological requirements set for offshore mining complexes and building of offshore mining systems for exploitation of solid mineral raw materials. Depending on mineral's sort, morphological structure of placer, ecological restrictions in mining and exploiting zone, quality demand for concentrates and products of processing, level of offshore mining systems the organizing can be quite different. As a rule, offshore mining systems consist of the following subsystems: extracting; concentrating; loading; transporting; industrial processing; mining and metallurgical; mining and chemical.

We would like to briefly describe the technological and ecological principles of exploitation of continental shelf's deposits and the organizational structure for extraction and processing of mineral raw materials below.

TECHNOLOGICAL AND ECOLOGICAL PRINCIPLES OF EXPLOITATION OF CONTINENTAL SHELF'S DEPOSITS

Alluvial deposits are a significant part of reserves of the shelf's minerals which are exploited effectively from economic point of view by means of seagoing dredges and suction-tube dredges. In these conditions the process of placer's exploitation foresees continuous extraction from the bottom of water area to lower border of placer), after which the underwater open pit or system of trenches remains at the bottom of water area. Thus, the exploitation of underwater placers is carried out using traditional technical means and technologies. These technologies imply a concept of continuous extraction of mining masses which inevitably results in complete extermination of biocenosis in the bottom part of water area due to its destruction together with minerals. Besides, extraction of mining mass is accompanied by an increase of turbidity by solid suspensions in water. Also, this process decreases water quality due to toxic substances of exogenous and endogenous origin. As a result, significant suppression of biocenosis all over the area of underwater exploitation can take place in case of large-scale exploitation of minerals.

The volume of placer's material in mining mass will not exceed 30-35% due to insignificant value of natural slope's angle, even when thickness of covering layer is compared to exploited placer. Taking into account that the portion of useful component in placer's material is considerably less than 100%, it is proved that the outcrop of useful component will be still less. So the use of traditional technologies for exploitation of underwater alluvial deposits is a developed dredging method. It provides for big extraction of mining mass having low content of useful component, while extraction of useful component contradicts with the ecological requirements of minimal possible damage to biocenosis, allowed only within its self-restoration ability. The most unfavorable thing is that the covering layer's material (under which placer is located) is of no interest/use in most cases, while costs for its extraction, lifting, separation of useful components from it, exceed the cost of useful components. For example, complex use of total volume of mining mass using tailings as construction materials is not always possible due to lack of closely located consumers of such products. It is impossible to increase exploitation selectivity at the expense of minimizing material extraction from the layer, covering the placer using technology of underwater placer's exploitation, realizing the above concept. Taking this into account, we suggest to exploit buried alluvial deposits by making holes. Such way is developing the ideas suggested in Patent of the Russian Federation №. 2018670.

A section through axes of adjacent stripping holes at the first stage of mountain mass exploitation limited to one of these holes is shown on Figure 1a; the final stage of this process is shown on Figure 1b. It is supposed to use a device mounted on a floating base 1, for realization of this method. This floating base has hydromonitoring devices 2 and 3 with sliding rotary pump column 4, concentrating pulley 5, providing a division of mining mass to useful component and tailings. Besides, a bunker 7 for gathering useful component and rock bunker 6 for temporary placing of tails are mounted on the side part of the floating base. 1 is not different from floating bases of offshore dredges. It is recommended that the distance between the longitudinal axes of hydromonitoring devises will correspond to max. diameter of chamber 8, extracted from hole 9. Hydromonitoring devises 2 and 3 have standard design. Pump column 4 of hydromonitoring device has pulp feed line, water piping and air compartment, being flexible hoses, placed inside one of them, which has the largest diameter. Hose bend-control is carried out by lamellar chain. Dressing pulley 5 includes mounted plants of gravitational and magnetic concentration. It is expedient to realize disintegration and classification of mining mass before its feeding with fractional heterogeneity with placer material. In these conditions it is necessary to have a certain number of concentrating lines (i.e., complex of gravitational-magnetic concentration).

Rock bunker 6 provides for smooth work load of hydromonitoring device 3. It is used in tailing stacking by excluding its dependence from the work of hydromonitoring device 2 and concentrating pulley 5.

Placer exploitation is made in the following way.

The initial position corresponds to the moment of finishing exploitation of the second chamber in the borders of extracted section. So this position corresponds to the position in which the first chamber is filled by concentrate tailings 10. These tailings were received under exploitation of the second chamber fully filled. During working, floating base is located in such a way so that rotary mechanisms of both hydromonitoring device's pump columns correspond along longitudinal axes of holes 9 and 13. That's why unimpeded lead-in of pump columns of hydromonitoring devices 2 and 3 into these holes is guaranteed after the mountain mass' exploitation around the first hole. The floating base 1 is moved in such way to provide a withdrawal of corresponding hydromonitoring device to the new working point. It is necessary the hydromonitoring device went out to the point, corresponding the position of the hole 13. Hydromonitoring aggregate 3 remains in the hole 13 and in filling of the chamber 12. After completing of this maneuver, the floating base is fixed in described position, for example, by putting anchors.

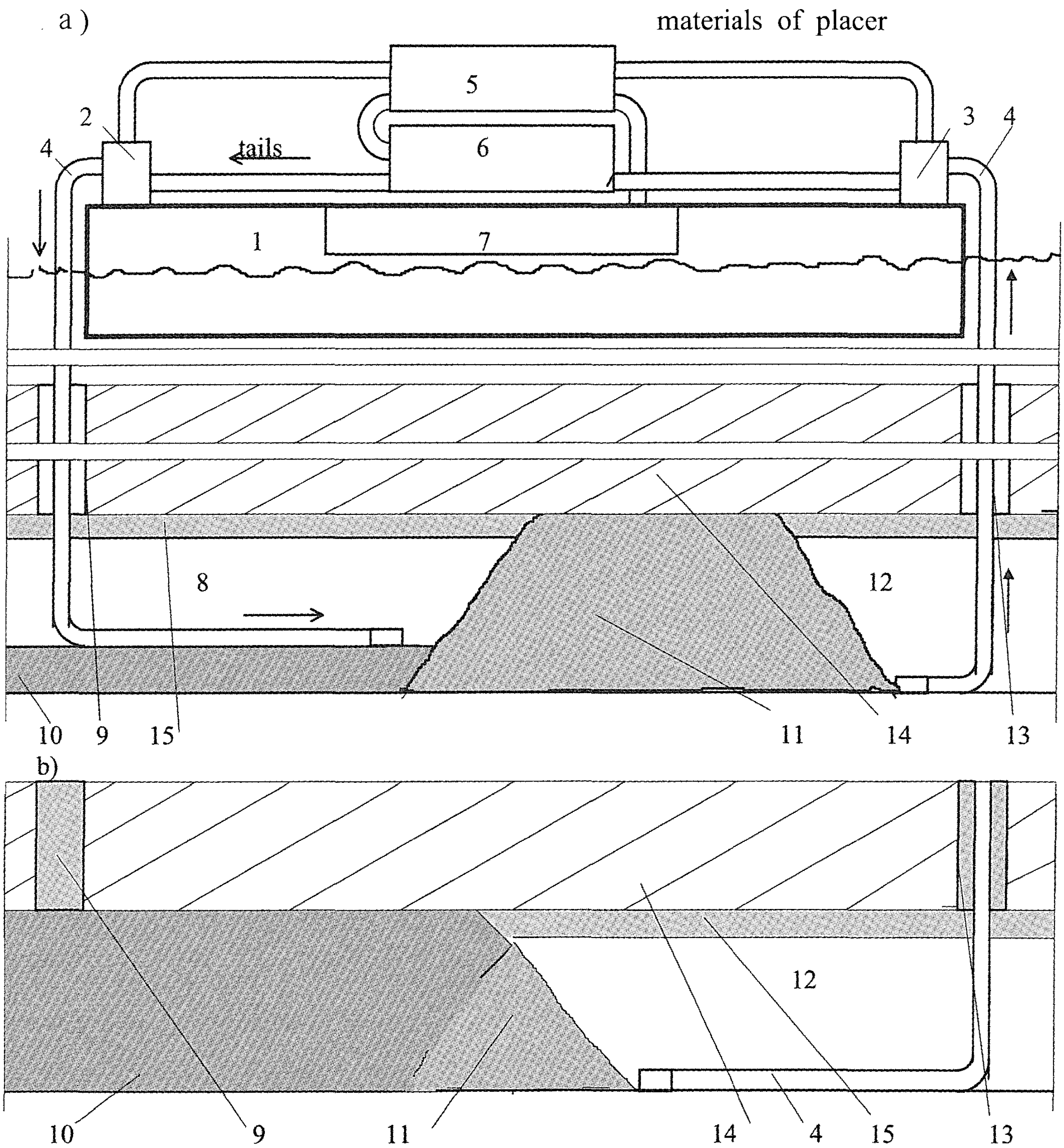

Figure. The scheme of the placer's exploitation: a) the initial stage of subsequent exploitation of the chamber and packing of the previous chamber; b) the final stage of subsequent chamber's exploitation and packing of the previous chamber. I - floating base; 2 and 3, accordingly, the first and the second hydromonitoring device; 4 - pump columns of the hydromonitoring devices; 5 - concentrating pulley; 6 and 7 - bunkers-storage devices, accordingly, of tails and concentrates; 8 and 12 - chambers; 9 and 13 - holes; 10 - layer of tails; II-placer; 14- covering thickness of the dead rock; 15 - supporting layer from the material with positive floating ability.

The placer 11 is revealed by the hole 13 (if the dense rocks of covering thickness 14 are available the placer is boring by plant, capable to move at the deck of the floating base (it's not shown on schemes). Then the nozzle of hydromonitoring device 2 is brought into the hole and pump column of this aggregate is tied with entrance of concentrating pulley 5. Simultaneously pump column of hydromonitoring device, placed in filling of the chamber 12, is tied with rock bunker 6.

And supporting layer 15 from granules of the material with small specific gravity(for example, polyurethane) is formed simultaneously with extraction of placer's material around the holes 9 and 13 (i.e. when the chambers 8 and 12 are formed). Capacity of this layer 15 is determined by compensation of difference in gravitational forces, causing the breaking of chamber's roof (rocks of covering thickness 14) and their own carrying capacity.

In the course of extraction of chambers the filling of extracted chamber 8 is realized. The chamber 8 was extracted by tails of material's concentration, excavated from the chamber 12 and so on. The filling of the previous chamber is realized with the extraction of the next chamber, concentrating tails of the material, extracted from this chamber. In these conditions, the material, extracted to the floating base 1, is divided into the useful component, accumulated in bunker 7, and tails of concentration, gathered in rock bunker 6. Then they are put into the goaf of filling chamber with water pipe-line's hose of the pump column 4, placed in this chamber.

Finishing this work (exploitation of one chamber and filling of the previous chamber) the pump column of hydromonitoring device 3 is extracted from the chamber 12 and it is stopped at the roof. Then granules are drawn off from the sustained layer 15, if their repeated use is envisaged. Pump column is extracted from the hole and the floating base 1 is turned to the new working position. After that all the process is repeated.

CONCLUSIONS

1. The cadastre module under is design and the initial data of certain shelf deposit makes it possible to establish the automated system, providing the information basis of all the stages of designing and construction of marine dressing complexes.
2. The analysis of mining-geological characteristics of the deposits and hydro-meteorological conditions of their exploitation, provided by the cadastre, gives the possibility to distinguish the demands for reliable, durable and technological parameters of the separate functional modules and to synthesize the optimum technological structure of marine dressing complexes for the exploitation of the deposits of Far-Eastern and Arctic seas shelf.

3. The richest resources of different solid minerals are on the continental shelf of the Far-Eastern seas. First of all, it is economically expedient to exploit alluvial deposits of titanium-magnetite, magnetite, zirconium and gold. The structure of marine mining systems depends mainly on type of placer, ecological limits in the zone of mining-marine exploitations and requirements to the end products of mineral raw material's processing.

4. The organization of joint companies for mining and processing of solid mineral resources should be oriented at the international relations with establishment of leasing, holding, consulting and other companies and firms.

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Abstract

Solid mineral resources cadastre of the Far-Eastern and Arctic seas shelf deposits is considered in this paper. The information, provided by the cadastre, is differentiated according to each deposit under consideration with distinguishing of on-shore (beach) zone, tidal zone (up 20 m deep) and off-shore zone(up 50 m deep) being made. The cadastre includes several information blocks:

- mining-geological characteristic of the deposit;
- hydro-meteorological conditions and aerodynamic local mode of occurrence of a placer;
- ice conditions of the sea (thickness of ice, periods of drifting and freezing and etc.);
- technological parameters of the placers;
- geographic, technical-economical and ecological descriptions of the area of the placers.

The condition, perspectives of underwater exploitation of World ocean continental shelf deposits as well as the description of mineral-raw material base of the Far-Eastern region of Russia are given in this paper.