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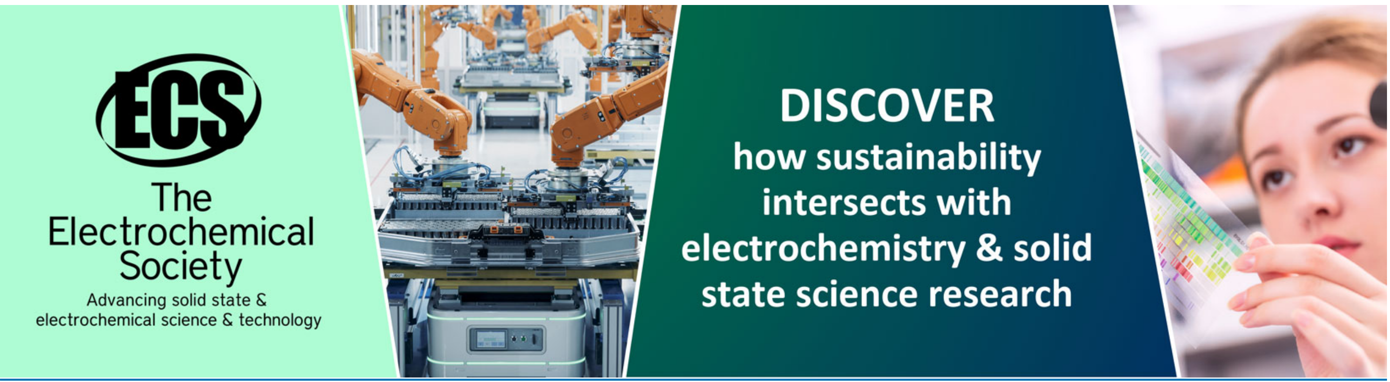

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Placer deposit mining method justification

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Abstract. The article highlights directions for improving placer deposit mining using dredges. Conditions for the use of dredging mining systems were analyzed. The existing technique for selecting dredging methods was described. Overburden, mining and disturbed land reclamation methods applied for longitudinal pillar and adjacent systems were analyzed. Relationships between overburden and mining parameters and reclamation indicators were revealed. Technical and economic assessment for various mining methods was performed. The article suggested accounting for overburden and reclamation indicators with regard to their sequence when justifying placer deposit mining methods.

1. Introduction

The current resource base is a resource which can be developed using dredges [1-2]. The search for solutions to the current problems of alluvial deposit mining aims to improve mining methods [3-8], including technogenic placer deposit mining [9, 10], reduction of losses and mineral dilution [11], improvement of the environment [12, 13].

One of the main distinctive features of the dredging method is the number of faces simultaneously mined by one drag, the presence of pillars and longitudinal movement of the loading face. For wide alluvial deposits, transverse and longitudinal systems with adjacent faces and pillar methods are used.

When selecting a mining method, technical and economic analysis of possible options is used. Method efficiency reflecting average daily dredge performance for single and adjacent faces is assessed [14].

Existing methods for selecting mining systems are based on the assessment of mining operations and do not take into account overburden operations which are important for deep placer deposit mining. Environmental components associated with disturbed area reclamation which are different for various mining methods (reclamation technology, volume, cost) have never been taken into account.

2. Material and methods

Pillar methods for placer deposit mining using dredges are analyzed. Parameters of the alluvial deposit are as follows: depth is 40 m, overburden thickness is 23 m, face width along the bedrock is 181 m. Mining equipment includes OM dredge – 431, ESh 20.90 and ESh 11.70 draglines, bulldozers. Research methods are graphic, economic and mathematical modeling.

Positive factors of the longitudinal pillar method (in comparison with an adjacent method):

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- Smaller simultaneously disturbed area, possibility of successive alienation of land for mining operations.
- Manageability of overburden, reclamation and development parameters by varying the width of the counter dredge moves.
- Creation of dumps for natural treatment of industrial wastewater outside the area of mining operations.
- Despite reclamation operations lag behind the first dredge move, it is possible to restore land across the disturbed area when developing reserves within the second dredge move and complete reclamation simultaneously with sand processing.

Factors decreasing system performance:

- When mining powerful sand layers, pillar loss and (or) sand dilution are inevitable.
- Under uneven metal distribution across the placer width, the amount of mineral resources during dredge moves is different.
- Reclamation operations lag behind mining operations.

Positive factors of the adjacent method (in comparison with the longitudinal pillar method):

- Reduced time gap between mining and reclamation operations.
- Averaged content of sand excavated by a dredge over the entire cross section of the bottom faces.

Factors decreasing system performance:

- Additional dredging operations and other auxiliary onshore operations, including energy supply.
- A large volume of dam construction operations.
- It is difficult to retain water in the dredging pit, in particular in winter caused by increased drainage through retaining structures.
- Larger land area is disturbed during overburden operations.
- Increased amount of landfill preparation operations and losses under the dam.

3. Results and analysis

Longitudinal pillar method.

When performing overburden operations, peat layers located within the first dredge move are removed into external dumps adjacent to the pit. Overburden overlapping sands within the second dredge move are located in external and internal dumps, and only external dumps can be dumped. Reclamation operations are carried out immediately after the first dredge move is completed, within the adjacent area and behind the open pit contour. Mining operations are performed by single counter-moves of the dredge leaving inter-move pillars.

Adjacent method.

The overburden rocks are removed by dragline excavators from the area across the adjacent dredge moves and are placed into external dumps near the quarry contour, including rock re-excavation. Reclamation operations are preceded by mining operations. Mining operations are carried out in two faces (semi-faces) within one dredge move across the placer.

Analysis of technologies for overburden operations with external and internal dumping by draglines for dredging systems with counter and adjacent moves shows that dredging parameters (face width) influence mining operations which influence re-excavation of dump rocks (Figure 1).

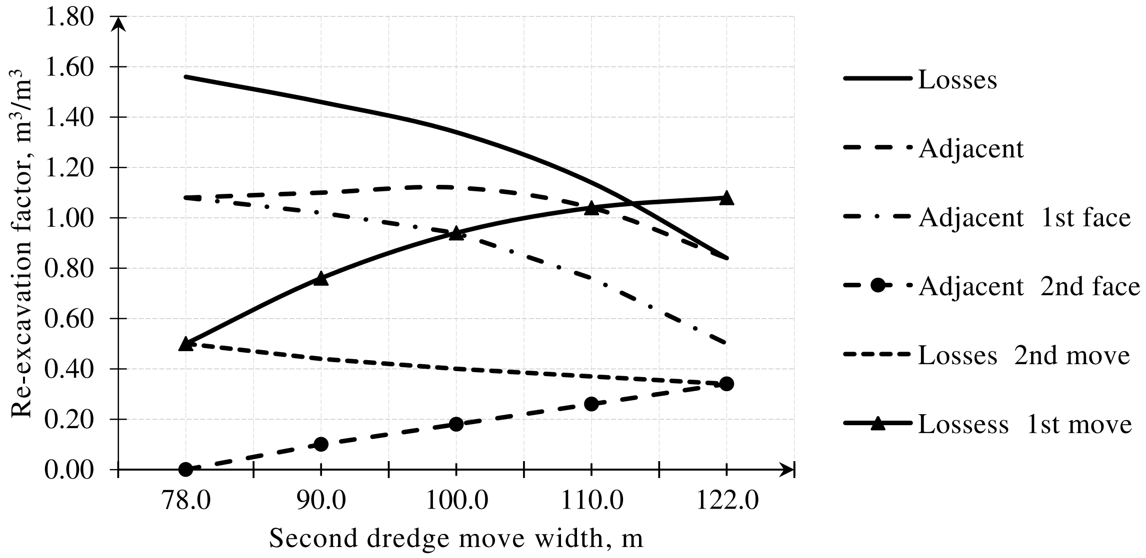

Figure 1. Relationship between a dump re-excavation factor and a dredge move width.

An increase in the second dredge move width (respectively, a decrease in the first dredge move width) reduces the volume of re-excavation during stripping operations. In technological schemes of stripping operations (for the pillar systems) when the overburden is removed from the overburden strip corresponding to the adjacent face width and placed in external dumps, the re-excavation factor increases from 0.5 m^3/m^3 to 1.07 m^3/m^3 with an increase in the second move width from 78 m to 122 m. Thus, changes in the second move width in the same range decrease the re-excavation volume from 0.5 m^3/m^3 to 0.34 m^3/m^3.

By controlling the width of the dredge moves with inter-move pillar losses and sand dilution, an increase in the second dredge move width relative to the first dredge move width reduces the re-excavation volume by 30 %. A two-fold decrease in sand dilution increases sand production within the first dredge move.

With the same placer width, the seasonal dredge performance of the adjacent method increases by 20%. Dredge performance at various face widths in the adjacent mining systems decreases by 3%. Comparison of the daily dredge utilization rate at a dredging face width varying from 65 to 125 m shows that its value for the longitudinal mining system is within 0.85–0.90, and for the adjacent system, it varies from 0,87 to 0,93. For the longitudinal system, metal loss in the inter-move pillar on the border of opposing faces 74 m and 117 m in width is about 4 %.

The environmental strategy of the mining enterprise is sometimes based on minimization of the costs for elimination of environmental damage. In this regard, in addition to technological and technical solutions, combined mining and reclamation operations should be carried out.

4. Discussion

Two competitive methods were analyzed when assessing performance of dredging operations under specific conditions of deep placer deposits.

The longitudinal pillar method involves stripping operations carried out according to the transport-free scheme by placing the overburden into the external dump when preparing sands for the first dredge move (re-excavation factor is 0.5 $m^3/m^{3)}$. Peat layers from the counter dredge move area are placed into the

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external and internal dumps (re-excavation factor is 0.34 m^3/m^3. Mining operations are carried out by counter-moves of the dredge with the first move width of 70 m and the counter move width of 110.9 m. During reclamation, the overburden is partially mined and dumped on the surface (Figure 2).

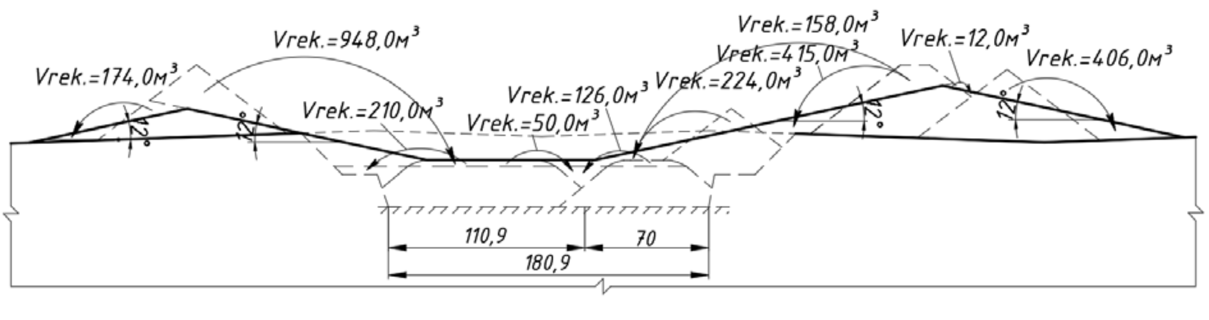

Figure 2. Profile of the restored surface (pillar mining).

In the adjacent system, mining operations are carried out by a single move with alternating mining of bottom faces 90,4 m in width, seasonal dredge capacity is 977 thousand m^3. Stripping operations are carried out according to the transport-free scheme across the width of the placer by placing dumps on either side of the open pit contour. The re-excavation volume reaches 1,13 m^3/m^3. Reclamation of disturbed areas involves flattening of dumps in the disturbed area and behind the mining area (Figure 3).

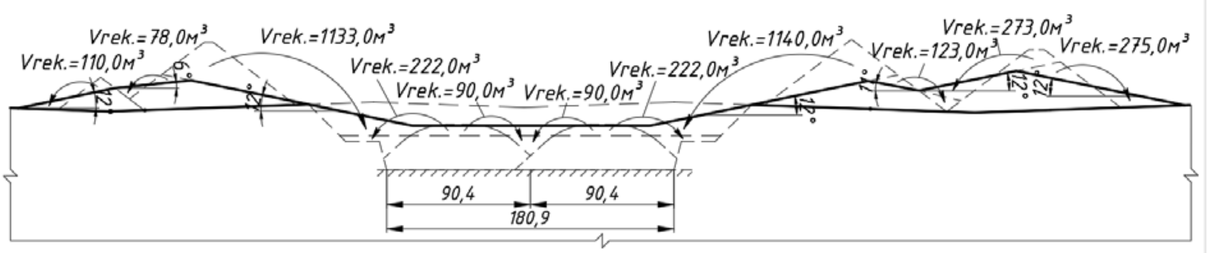

Figure 3. Profile of the restored surface (adjacent mining).

Calculated technical and economic performance of the analyzed mining methods (Table 1) allow us to conclude that despite environmental damage, the adjacent method is more effective due to a decrease in sand loss, an increase in annual metal production and reduced mining terms.

Table 1. Technical and economic indicators for deep placer deposit mining.

Indicators	Pillar mining (longitudinal)	Adjacent mining (adjacent-longitudinal)
Dredging width, m	74-117	95
Annual sand extraction, thousand m^3	814	977
Deposit mining term, years	11.6	9.6
Disturbed land area, h	147	167
Reclamation share in overburden, %	54	75
Share of environmental cost in the operating cost, %	17.5	21.8
Share of environmental cost in capital investment, %	12.4	13.3

Financial flow dynamics analysis for the adjacent method (Figure 4) shows that when transferring reclamation costs to later periods, the effect of positive financial flows decreases. For example, four-year reclamation reduced financial inflows by about 30 %.

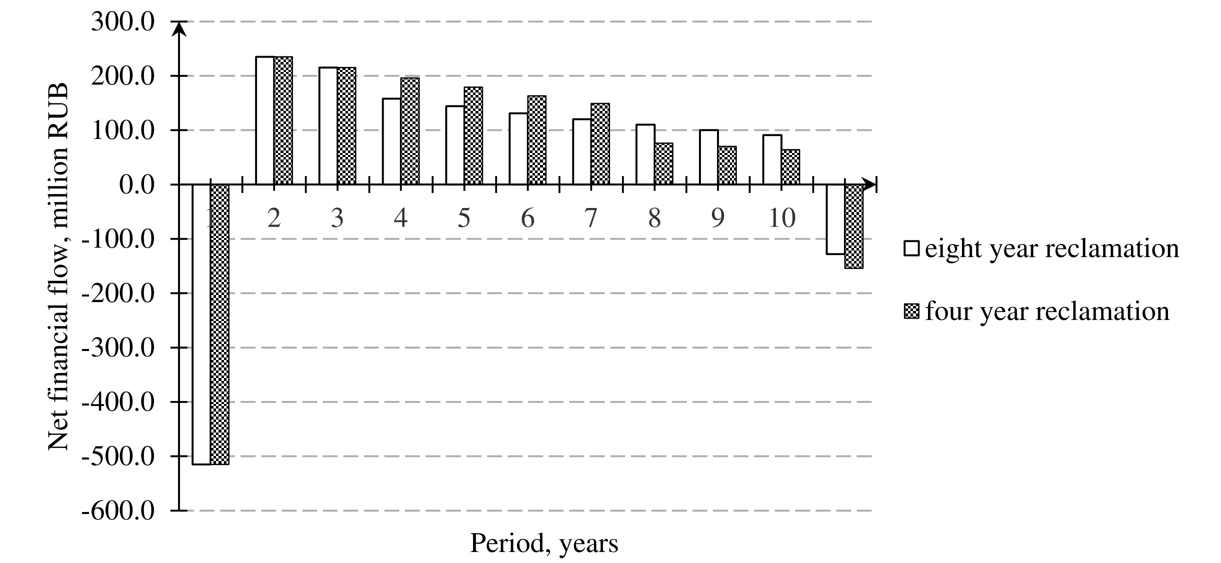

Figure 4. Dynamics of financial flows of the enterprise for the adjacent mining system.

5. Conclusion

Thus, the studies on adjacent and pillar mining identified that in justifying the deposit dredging method, it is necessary to take into account technological schemes and parameters of overburden and reclamation operations, routine and range them by their volumes.

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