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To cite this article: L V Petrova and A N Petrov 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **459** 042094

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# The Technology of Opening and Mining Sites of Complex Occurrence of Placer Deposits in Permafrost Conditions

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**Abstract.** The article presents technical solutions for the opening and development of sites of the placer deposits with upper «hanging blocks» in the conditions of the «Obryv-Razvalisty-Promezhutochnyj» placer deposit. According to the experience of the opening workings in placer deposits of the North-East of the Russian Federation, a scheme has been adopted for opening mine fields by inclined conveyor and scraper inclines using access drifts.

The choice of the most rational scheme of mine field preparation in the conditions of the «Obryv-Razvalisty-Promezhutochnyj» deposit is based on many years of experience in underground mining of placer deposits in the North-East of the Russian Federation.

According to the results of the analysis, a chamber-longwall method was selected.

The peculiarity of the field, the presence of “upper hanging blocks” and lower blocks on the placer rock bed, determines the interposition and parameters of stopes and inter-chamber pillar.

## 1. Introduction

The specificity of exploitation of permafrost deposits includes the following natural factors that determine development technology and complicate mining operations: severe climatic conditions and the frozen state of rocks difficult and inaccessible terrain and specific conditions of occurrence, vastness and sparsely populated territory and its remoteness from the main industrial regions of the country, complicating operating conditions and constantly deteriorating quality of mineral raw materials (metal-bearing sand) [1, 2].

The «Obryv-Razvalisty-Promezhutochnyj» deposit is placer deposit of gold, located in the Oymyakon district of the Republic of Sakha (Yakutia) in the permafrost distribution zone.

According to the degree of stability of the peat roof, they are stable and medium stable.

The average section of peat is represented by two layers: the upper one, consisting of frozen and seasonally thawed alluvion, clays, with soil and woody plant residues up to 3 m thick and the lower one, composed of frozen pebbles of various genesis, sometimes bouldery with sandy-loamy-clayey and silty aggregate, less often peat bogs with a capacity of up to 100 and more meters [3-7].

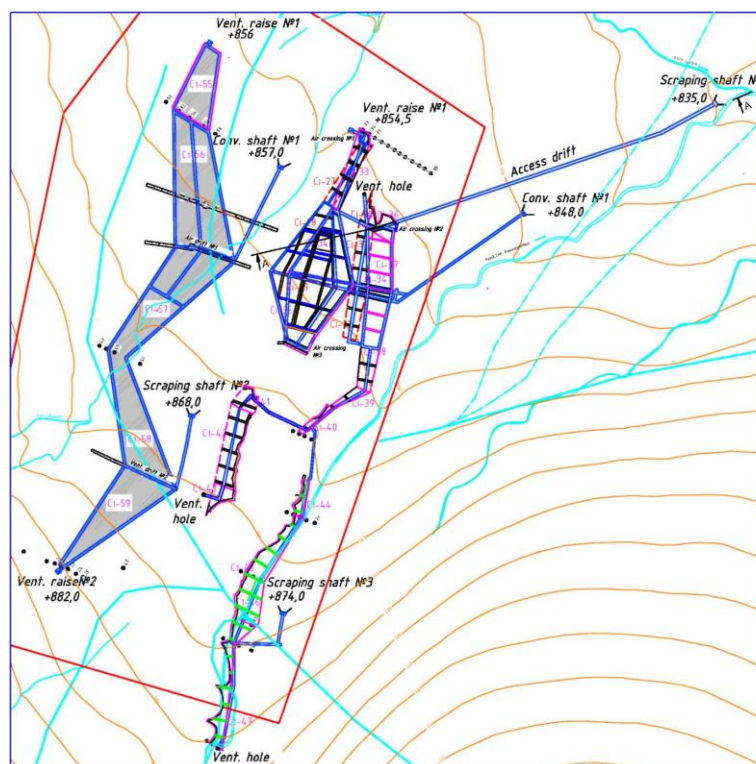
## 2. Methods and materials

An analysis of the underground mining experience of permafrost placer mining deposits in the North-East of the Russian Federation made it possible to justify the scheme of opening mine fields with inclined conveyor and scraper shafts with the penetration, if necessary, of air pit (rising) on the flanks of mine fields [2, 8-11].

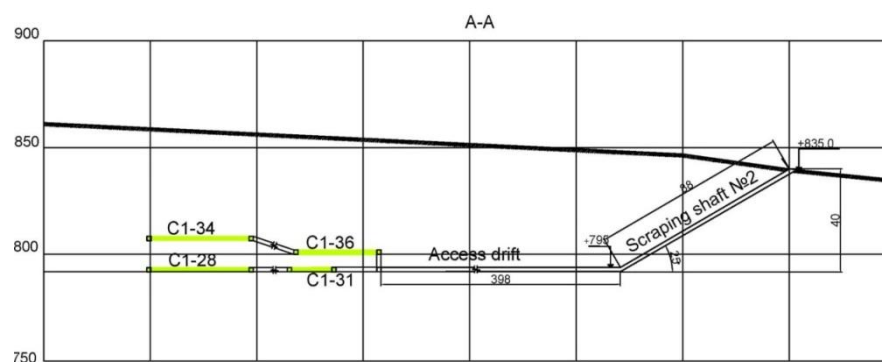


The location of the opening inclined shafts is along the contour of commercial reserves. The inclined shaft are carried out by a blasting method, have two compartments - cargo, equipped for lifting sand with a conveyor KL-800 (2L80U) (with an angle of inclination of the shaft up to  $18^\circ$ ) and a scraper equipment 110LS-2CMA (with an angle of inclination of up to  $25^\circ$ ) and a manway compartment [12].

The locations of the inclined shafts relative to the boundaries of the mine field and the terrain are selected taking into account the maximum allowable difference in elevations between the earth's surface and the bedding rock (up to 40 m) to ensure non-mechanized lifting of people, reduce the time of preparation of the mine field and ensure a sufficient front line. The depth of the layers of mine fields no. 1 and 4 does not allow the use of a generally accepted scheme with the inclined shafts landing on rock-floor, at the boundaries of the placer, and therefore an opening scheme using field approach drifts was applied to these mine fields (Fig. 1, Fig. 2).



**Figure 1.** The scheme of deposit opening with the use of access drifts on allotment №4. The surface plan.



**Figure 2.** The scheme of deposit opening by scraping shaft №2 with the use of

access drift on allotment №4. The section.

With the adopted scheme of opening, the depth of the shafts no. 2 and no. 3, respectively, is 40 m and 24 m, which makes it possible to provide non-mechanized descent and ascent of people, and to position the conveyor shaft no. 1 with a depth of 53 m, intended for delivery of rock mass, at the border of the mine field with landing on rock-floor.

A chamber-lava development system was adopted as the main one during the exploitation of the placer deposit, the application of which ensures high safety of mining operations with effective top control, minimal consumption of fixing materials, high reliability of refinement of the contours of the placer during sinking of chamber-lavas, high productivity and technical economic indicators [13-16].

Excavation sites are represented mainly by narrow placers. An exception are the geological blocks C1-34, C1-35, C1-56, C2-26, the width of which is 80-112 m. According to [5], in placers with a width of 50 ... 60 m to 120 m and a length of up to 300 m, the excavation sections during preparation are divided into double-sided panels.

The development of reserves is carried out by lava chambers, located mainly across the spread of placers. Top control is carried out by leaving rigid inter-chamber chain pillars. The direction of work in the chamber is along the strike of the placer [17-20].

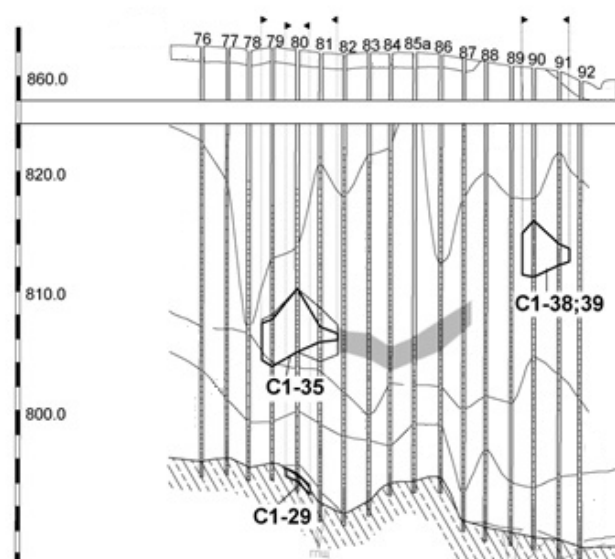
In the conditions of the Obryv-Razvalisty-Promezhutochnyj deposit we use the main provisions of the Turner-Shevyakov hypothesis to determine the parameters of inter-chamber pillars (ICP).

Table 1 shows the results of calculations of the ICP parameters at a development depth of more than 60 m.

**Table 1.** ICP parameters calculation results.

Camera width (m)	ICP width (m)
$b < 10$	3.3
$b < 30$	1.65
$b > 60$	2.6

A feature of the sand reserves of mine field no. 4 is the presence of "upper hanging blocks" (block C1-35), i.e. part of the strata is located on a false bedrock in the overlying rocks, and below them are sand layer on bedrock (block C1-29) (Fig. 3).



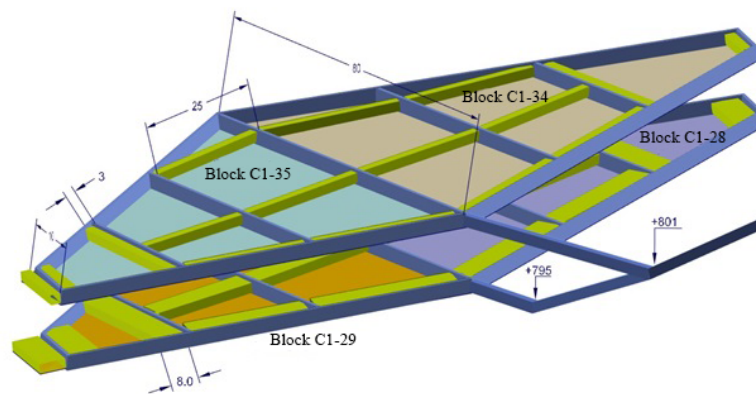
**Figure 3.** The geological record along the p.l.16.

The thickness of the sands in the bedrock of mine field no. 4 ranged from 1.0 to 2.27 m (an average of 1.2 m), and the thickness of the sands of the interlayer zone II was from 0.75 to 2.6 m (an average of 1.57 m).

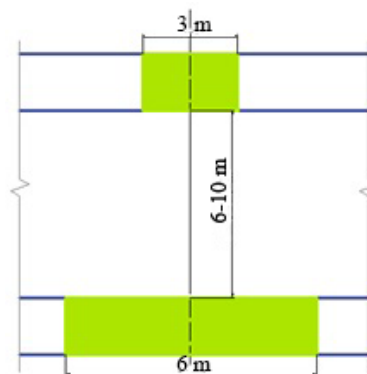
Such an arrangement of reserves requires a different approach to determining the pattern of mutual arrangement and sizes of chambers and pillars of upper «hanging blocks» and underlying reserves.

### 3. Results and discussion

It is recommended to take the coaxial arrangement of the inter-chamber pillars of the upper «hanging blocks» and the lower blocks on the placer rock bed, for uniform distribution of rock pressure on the pillars (Fig. 4, Fig. 5). In this case, the width of the IPC of the upper «hanging blocks» should be taken to a maximum of 3.1 m, and the lower blocks - 8 m. The width of the chamber on the bedrock should not exceed 25 m.



**Figure 4.** The layout of the upper "hanging blocks" and lower blocks.



**Figure 5.** The coaxial location of inter-chamber pillar of upper «hanging» and lower blocks.

Recommended ICP parameters are given in table 2.

**Table 2.** ICP width determination.

The type of reserves, mining depth (m)	ICP width (m)		
	The width of chamber (m)		
	30	20	10
The reserves in upper «hanging» blocks, up to 60 m	3.1	2.2	1.1
The reserves in bedrock blocks, more than 60 m	8.0	6.0	5.0

The stoping begin after cutting of 3.0 m in width over the entire length of the chamber.

#### 4. Conclusion

The issue of the scheme and method of opening the deposit was solved, the location scheme of the shafts relative to the mine field was determined taking into account the terrain. Acceptance of mine openings by inclined conveyor and scraper shafts with a penetration, if necessary, of air pits (rising) or ventilation holes on the flanks of mine fields.

A scheme has been adopted for opening mine field no.4 by inclined conveyor and scraper inclines using access drifts.

Based on the analysis and generalization of the underground mining experience of permafrost placer deposits of the North-East of the Russian Federation, a chamber-longwall mining was selected.

To develop the placer areas lying on the false bedrock (upper «hanging blocks»), the inter-chamber pillars were determined and the arrangement of chambers and pillars of the upper «hanging blocks» and the lower blocks on the main bedrock was compiled.

It is recommended to accept coaxial arrangement of inter-chamber pillars of upper «hanging blocks» and lower blocks on the main bedrock for uniform distribution of rock pressure on pillars. In this case, the width of the ICP of the upper «hanging blocks» is 3.1 m, and the lower blocks - 8 m. The width of the chambers on the main bedrock should not exceed 25 m.

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### Acknowledgments

The decisions laid down in the article are recommended in the project for the development of placer gold deposits.