Determination of main vertical ore-lift shaft location in two planes

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Determination of main vertical ore-lift shaft location in two planes

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Abstract. A method of determination of main vertical ore-lift shaft location considering the difference between freight traffics is presented. The method is based on the rule of academician L D Shevyakov: “When freights are concentrating on one line and considering the minimum transportation work the main vertical ore-lift shaft must be located in a place of concentrating of this freight. If this freight would be summed with all the freights from the left, the result would be more than the freights from the right. If this freight would be summed with all the freights from the right, the result would be more than the freights from the left”.

1. Introduction
Location of main vertical ore-lift shafts is usually determined by safety factor [1, 2]. Main vertical shafts are usually constructed at some distance from the boundary of the rock displacement zone on the surface and considering the convenient location of the shaft collar and the surface mine infrastructure. Besides, costs for underground and surface transportation of ore and rock mass, delivery of materials to workplaces, ventilation of underground openings, time spent by people moving underground to their workplaces are considered [3, 4].

2. Materials and methods
This article is written according to materials from the “Uzhuralzoloto Group Companies” corporation, Kochkarskoye deposit, mine “Tsentralnaya”. Kochkarskoye deposit is located in the northern part of Kochkarskoye ore field, which is confined to Plast’s mass of plagiogranites [5, 6]. At the moment, two ore zones are being mined: Central and Northern. Ore bodies are thin quartz veins with complicated morphology, including double, triple veins and lenses [7-10]. Veins have sub latitudinal strike from north to east. The internal structure of veins is complicated by spatially isolated lenses inside. Horizontal strike of veins is about 300-600 meters, depth is more than 1000 meters. Thickness of veins is about 0.5-1 meter, inclination varies from 65 to 80 degrees. Enclosing rock and ore are characterized as stable. Traditionally, location of the main vertical ore-lift shaft is determined in one plane of symmetry of freight traffic. However, in case of complicated occurrence of ore bodies when ore bodies are analyzed in 3 dimensions it would be more rational to determine the location of main vertical ore-lift shaft for this special case in two planes of symmetry of freight traffic. In order to show the principle of determination of the location in two planes the Central ore zone is taken as an example. The Central ore zone includes 8 ore bodies. This zone was mined to a level of -700 m, so new levels are taken as an example: -750 m, -800 m, -850 m. An opening scheme of these new levels is similar to that used before (Fig. 1, Fig. 2).
3. **Research**

At the beginning, balance reserves of ore, lengths of the ore bodies along the strike and dip, distances between the ore bodies along the strike and dip should be determined. In this case, balance reserves are determined for each vein: Severo-Nikolayevskaya – 36 450 tons of ore, Sutorminskaya – 40 500 tons of ore, Degtyaro-Kuznetsovskaya – 28 350 tons of ore, Novaya – 182 250 tons of ore, Oktyabrskaya – 81 000 tons of ore, Bzhukovskaya – 40 500 tons of ore, Yuzhnaya Aleksandrovska – 243 000 tons of ore, Sretenskaya – 162 000 tons of ore. Lengths of the veins along the strike and dip and distances between the ore bodies along the strike and dip are taken from the mine plan of level -850 m (Fig. 3, Fig. 4).
Equations for solving the problem of locating the main vertical ore-lift shaft in two planes considering the difference between freight traffics in general are the result of the equations (for X and Y respectively):

\[
B_i \left( X - \frac{l_i}{2} \right) + B_{i+1} \left( X - l_i - C - \frac{l_i}{2} \right) + B_{i+2} \left( X - l_i - C - l_{i+1} - \frac{l_i}{2} \right) = B_i \left( X - \frac{l_i}{2} \right) + B_{i+1} \left( X - l_i - C - \frac{l_i}{2} \right), \quad (1)
\]

\[
B_i \cdot Y + B_{i+1} \cdot (Y - b_i - M_i) + B_{i+2} \cdot (Y - b_{i+1} - M_{i+1}) = B_i \cdot Y, \quad (2)
\]

where \( B_i \) – balance reserves of ore body; \( l_i \) – length of ore body along the strike; \( C \) – distance between the ore bodies along the strike; \( b_i \) – distance between the ore bodies along the dip; \( M_i \) – length of ore body along the dip.

To the left and right side of equality sign, there are the values, relating to the left and right “flanks” respectively (Fig. 3, Fig. 4). The result of the equations for the case study is:

\[
40500 \cdot (X - 50) + 162000 \cdot (X - 100 - 117 - 100) + 28350 \cdot (X - 100 - 117 - 200 - 188 - 50) = 81000 \cdot (X - 100) + 36450 \cdot (X - 200 - 74 - 50)
\]

\[
121500 \cdot Y + 60750 \cdot (Y - 57 - 24.5) + 243000 \cdot (Y - 445 - 1.5 - 57 - 24.5) = 40500 \cdot Y
\]

\( X = 372; \ Y = 255. \)
4. Results
Figure 5 shows the actual location of the determined optimal ore-lift shaft coordinates in the plan of the level -850 m.

![Figure 5](image)

**Figure 5.** A plan of level –850 m with plotted coordinates of the main vertical ore-lift shaft location

As a result, the received data show a possibility to change the development scheme for more efficient ore haulage and transportation. As an example in the obtained coordinates, the blind shaft could be sunk (Fig. 6).

![Figure 6](image)

**Figure 6.** An axonometric development scheme for proposed more efficient ore haulage and transportation

To estimate the benefits of the proposed scheme, the analysis was made by the following factors: horizontal drifts length, openings construction and ore transportation costs. For the opening scheme chosen in the mine project, the horizontal drifts length is 6 307 meters. Overall openings construction costs are 19 536 420 USD, ore transportation costs at an productive capacity of 250 000 tons of ore per year are 824 010 USD. When the main vertical ore-lift shaft location is determined by using the presented method horizontal drifts length decreases to 5 068 meters which therefore affects the openings construction and ore transportation costs. The costs for the openings construction decreased to 11 969 965 USD and ore transportation costs at an productive capacity of 250 000 tons of ore per year are 662 134 USD.

5. Conclusion
The presented method of determination of the main vertical ore-lift shaft location in two planes enables one to locate the main vertical ore-lift shaft in the center of freight traffics in a situation when
occurrence of the ore bodies is complicated. Moreover, this method allows one to significantly decrease the length of the horizontal drifts, construction and transportation costs.

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