Enhancement of lost ore production efficiency by usage of canopies

Vladimir Golik

Doctor of Sciences, Professor,
Geophysical institute of the Vladikavkaz Russian Academy of Sciences,
RNO Alania, Vladikavkaz

Vitaly Komashchenko

Doctor of Sciences, Professor,
Belgorod State National Research University,
Belgorod, Russia

Vladimir Morkun

Vice-Rector for research, Doctor of Science, Professor,
Head of Computer Science, Automation and Control Systems department
State Higher Educational Institution Kryvyi Rih National University, Ukraine

Vladislav Zaalishvili

Doctor of Sciences, Professor Head,
Geophysical institute of Vladikavkaz scientific center of RAS

Abstract
Characteristic of the problem of lost ore production is given. The results of usage of metal-cable, wood-cable and cable-stayed load-bearing and transecting canopies in ore mine practice are given. Parameters of construction of continuous load-bearing ferroconcrete ceiling are presented in details. The conclusion that lost ore production increases raw material base and restores the health of the economy of mining enterprises is made.

Key words: PRODUCTION, LOST ORES, CANOPIES, ORE MINE, RAW MATERIAL BASE, ECONOMY, ENTERPRISE.

Lost ore production is characterized by increased dilution by overlying and enclosing rocks in the output process [1, 10-15]. Mitigation of the increased dilution in the output is tried to be reached through minimizing rocks admixing by usage of artificial constructions: continuous load-bearing ceiling, concrete-anchor rigid bearing, wood-cable and metal-cable flexible transecting, cable-stayed flexible load-bearing canopies [2]. Methods of ore quality management admit great divergence in norms of extraction losses and dilution. Processes of output quality management are systematized in Table 1. Canopies provide enclosure of stowing from overlying rocks above and from massif face. Cables and metal bands bear the main load (Fig. 1). A plot of the deposit of “Zaozernoe” (North Kazakhstan) [3] (Fig. 2) has been worked under a flexible wood-cable canopy.

Table 1. Typification of technologies of running ore quality enhancement

Type	Options	Application conditions
Injection	according to the: type of fixing agent; time of reinforcement; volume of reinforcement; object of reinforcement	homogenous broken massif with sufficient permeability without clay intrusions
Canopies	according to the: performing function; material; structure; mobility	homogenous broken massif with sufficient mobility of displacements
Ceilings	according to the: structure; combining elements; time in use; strength	integrated on massif discreteness of hard rock with inclusions of solid rocks

Ore dilution under the canopy turned out to be three times less in comparison with the index of base variant and amounted to 14%. The major part of the ore (up to 80%) was put out with the dilution of 5-15%. Base variant without canopy is characterized by extraction of the major part of the ore with dilution of 30-60% and only about 15% of ore with dilution of up to 15%.

Cable-stayed canopy was used in working ceilings and entry pillar. In the first case it was installed on a board gate of scraping of overlying block. The ceiling and the entry pillar were caved in and set after working the underlying block. In the second case the block including the ceiling and the entry pillar were worked with sub-level shrinkage. Canopy was installed in each sublevel. Working of underlying sub-level began after the caving of canopies of overlying sub-level and filling of cavities(Fig.3).

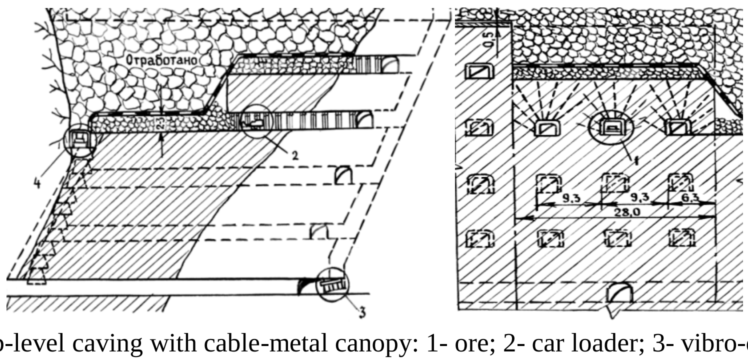

Figure 1. System of sub-level caving with cable-metal canopy: 1- ore; 2- car loader; 3- vibro-drop-hole; 4- a machine for canopy installation

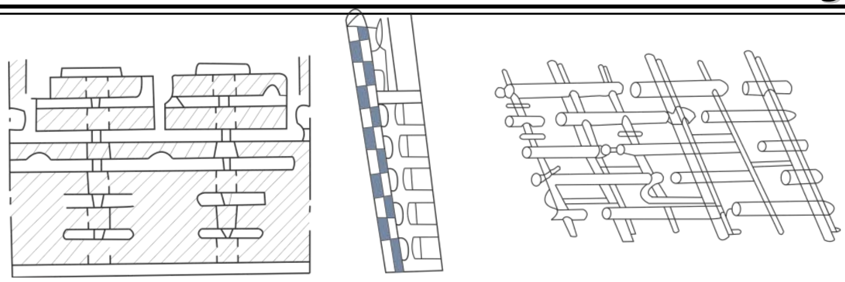

Figure 2. System of sub-level caving of ores and rocks with wood-cable canopy

Drill holes with the diameter of 45-46 mm and the depth of 1.5 – 3.0 m were drilled at the height of 0.2-0.4 m from the ground in the mine. With the use of sand-cement mortar the wires were put in. A wood deck or a net made of wires with a 0.5 x 0.5 cell was put onto the guy wires. Cable-stayed canopy was installed in sublevel drive. Drill holes with the depth of 1.9 – 2.1 m 25 –30^0 angularly to the horizon were drilled for installation of canopy in the walls of the drive at the height of 0.2 m from the ground. Drill holes with the diameter of 56 mm were drilled with an interval of 1.5 m. Then they were filled up with M-300 cement mixture and pieces of wire with the diameter of 30.5 mm were put in. Scaffolding with the diameter of 18 – 20 cm and the length of 3 m was put onto the wires fixed in drill holes. About 37% of the stowing came out with the dilution up to 15% at the total dilution of 27%. Wall rocks composed the main mass of diluting rocks.

Continuous canopies provide maximum effect. Concrete rigidity of continuous load-bearing ferroconcrete ceiling is 6-7 MPa at uncovering of ceiling of 9-12 m. Ceiling is constructed by ore extraction with the help of the system of horizontal layers with consolidating stowing. Ferroconcrete roof bolts with the diameter of 16 mm, the length of 1.5 m and dipping up to 0.7 m at every 1 m are installed in mines and artificial roof with the aim of providing combined action of canopy elements. The length of the segregated section is 20 m [4].

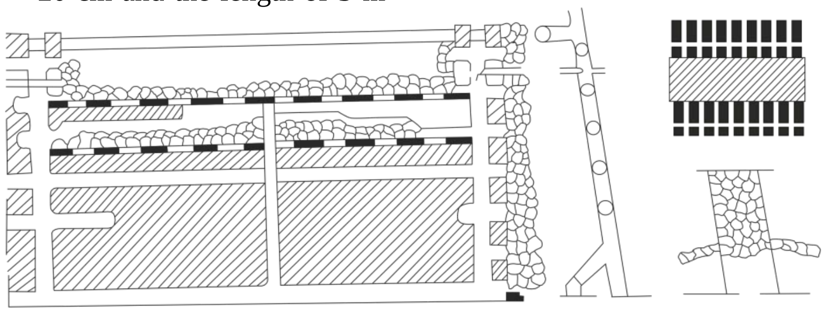

Figure 3. System of sub-level caving of ores and rocks with cable-stayed canopy

Canopies are in-demand most of all in a case when deposits are developed in near-surface areas. Ferroconcrete roof bolts with the diameter of 30 mm and the length of 2 m are installed in the walls of mines at the step of 1 m for creation of artificial ceiling. Reinforcement is set on the ground of mines. Characteristic strength of consolidating mixture rigidity is 6-7 MPa. The step of the formed ceiling varies from 3-4 m to 12 m and more. Ore mass is covered with the mixture with increased cement content (300 kg/m^3) and minimal water quantity for formation of the crust of cement on the ore top which blocks cement mortar penetration into the ore. Then the main volume of consolidating mixture is supplied (Table 2).

Rigidity of consolidating mixture σ_R from the assumption of stability of vertical uncovering of artificial massif [5]:

$$\sigma_R^U = \beta_1 \sin^2 \varphi \left(q_1 + 0.5 \gamma_3 h \right) K_3, \qquad (1)$$

where $\beta_1 = [\sigma_R^U] / [\sigma_{AW}^R]$ is the coefficient, which accounts the ratio between the ultimate compressive strength of stowing samples σ_R^U and their shearing strength σ_{AW}^R; $\varphi = (90 + \rho)/2$ -

is the slope angle of the ground cut, degree; ρ- is the dip angle of the artificial massif, degree; q_i – is the weight load of the rocks, MN/m^2; h – cell height, m; K_3- is the safety coefficient of stowing rigidity; γ_3- volume weight of the stowing, t/m^3.

Table 2. Rigidity of consolidating stowing at the layer height over 2 m

Indices	Parameters			
Width and height, m	15 x 6	15 x 9	15 x 12	15 x 15
Length, m	5.6	7.8	9.4	10.6
Rigidity, megapascal (28 days)	3.0	4.2	5.1	5.7

For conditions of Sadon deposit (RNO-Alania) an economic-mathematical comparison of the variants with caving was made: 1 –according to the base technology; 2 – under the canopy. Increased losses and ore dilution are inevitable at low production costs in variant 1. Economic damage from realization of this hazard cannot only amount to the costs of produced commercial components but also exceed it [6-7]. The problem of the rise of the running ore quantitative parameters by means of ore and rocks separation by canopies includes the following tasks [8-10]: improvement of constructions for running ores security from rocks; establishing borders and efficiency of ore and rock division by canopies; development of constructions of transecting and load-bearing canopies; determination of efficiency of lost ores output.

Conclusions

Value of dilution at lost ores output is decreased by engineering techniques including the usage of load-bearing and transecting canopies. Improvement of produced lost ores quality is an essential element of economic rehabilitation of mining enterprises.

References

1. Komashchenko V. I., Golik V. I., Drebenshtedt C. (2010). Influence of activity of the prospecting and mining industry on environment. KDU, Moscow
2. Golik V.I., Komashchenko V. I. (2011). Ways of the exit of mining production from present ecological-technological crisis. *Problems of regional ecology*, No 4, p.p. 67-75.
3. Golik V.I., Komaschenko V.I. (2010). Environmental technologies of massif control on geomechanics base. KDU, Moscow
4. Golik V.I., Polukhin O. N., Petin A.N., KomashchenkoV.I. (2013). Environmental problems of ore fields of KMA. *Gorniy Zhurnal*. No 4, p.p.91-94.
5. Yakimenko A.D., Golik V.I. (2004). Improvement of reworking technology of technogenic deposits. *Non-ferrous metallurgy*. No 1, p.p. 2-9.
6. Golik V.I. ,Komashchenko V. I. Stradanchenko S.G. (2011). Influence of losses and impoverishment on indicators of operation the field. *Mine surveying and subsurface use,* No 5, p.p. 17-20.
7. Rakishev B.R. (2013). Complex usage of ore in the enterprises of non-ferrous metallurgy of Kazakhstan. *Gorniy Zhurnal*, No 7, p.p. 67-69.
8. Sekisov G.V., Rasskazov I.Y. (2014). Creation of a research and production mining and processing complexes for innovative supporting of mining industry. *GIAB*, No 9, p.p. 113-121.
9. Kantemirov V.D. (2014). Technologic features of the development of new raw material bases. *GIAB*, No 6, p.p. 369 – 373.
10. Morkun V., Tron V. (2014). Ore preparation energy-efficient automated control multi-criteria formation with considering of ecological and economic factors, *Metallurgical and Mining Industry*, No5, p.p. 8-11.
11. Morkun V. S., Morkun N. V., Pikilnyak A.V. (2014). Iron ore flotation process control and optimization using high-energy ultrasound, *Metallurgical and Mining Industry*, No2, p.p. 36-42.
12. Morkun V., Morkun N., Pikilnyak A. (2014). The gas bubble size distribution control formation in the flotation process, *Metallurgical and Mining Industry,* No4 , p.p. 42-45
13. Morkun V., Morkun N., Tron V. (2015). Identification of control systems for oreprocessing industry aggregates based on nonparametric kernel estimators, *Metallurgical and Mining Industry*, No1, pp. 14-17.

14. Morkun V., Tron V. Goncharov S. (2015). Automation of the ore varieties recognition process in the technological process streams based on the dynamic effects of high-energy ultrasound, *Metallurgical and Mining Industry*, No2, pp. 31-34.
15. Morkun V., Morkun N., Pikilnyak A. (2014). Ultrasonic phased array parameters determination for the gas bubble size distribution control formation in the iron ore flotation, Metallurgical and Mining Industry, No3, p.p. 28-31.