ELIMINATION OF ABANDONED FLOODED WORKINGS DURING SHAFT SINKING AT YUZHNAYA MINE

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ABSTRACT

Two new deep shafts sunk at Yuzhnaya mine encounter a worked-out horizon at a depth of 210 m in Nezhdannaya mine which will be flooded and eliminated.

The paper presents experience gained in the course of design and execution of operations on sealing the worked-out face more than 1 m thick encountered by the mine shafts.

The sealing operations have been carried out via boreholes drilled from the ground surface by the injection of clay-cement grout. The presented technique of sealing is characterized by high reliability, usage of inexpensive and long term grouts, and rather simple technology.

INTRODUCTION

During the construction of up-to-date deep mines the vertical shafts must intersect, in some cases, the abondoned faces of old small mines. The worked-out horizons of such mines are generally subjected to flooding because there is no profitableness to maintain pumping.

Deep sinking of new shafts through flooded or to be flooded abandoned mine workings requires designing and executing special procedures to protect the shaft from strata water makes, and to eliminate the failor and damage of mine shaft lining and equipment in the zone of loose rock encountered in the caved roof of workings.

Executed operations provide the possibility to make a conclusion on the efficiency of eliminating the abandoned workings and consolidating their caved roof by grouting with high-viscous, plastic clay-cement grouts. The clay-cement grouts used for the purpose are easily injected via lengthy pipings by piston pumps, maintain a low spread-out in subsurface large voids under the influence of gravitational forces and simultaneously are capable to penetrate into fissures with an opening up to 0.1 mm, ensure sufficient strength of a water-sealing curtain at high hydrostatic pressures of strata water, are resistant to aggressive corrosion and suffosion attack of strata water, remain plastic after gaining strength that results in their ability to withstand impact loads and potential rock movement.

BASIC PRINCIPLES OF DEVELOPMENTS

Experience in the field of grouting of large karstic voids approved by experimental studies on special models indicates that there are two qualitatively different cases in the formation of water-sealing curtains during grout injection.

1. In small fissures the propagation of grout proceeds in a pressure regime radially from the injection point without or with its displacement along the strike of fissures. The water sealing curtain has approximately the shape of an elliptical cylinder.

2. In large fissures and other underground voids, for example in mine workings, the formation of a water-sealing curtain proceeds in a pressure-free regime. It is characterized by the grout accumulation in the floor of a mine working and only at the last stage, when the grout reaches the upper point of the void, the pressure regime may arise. There is an individual methodology for calculating the size and shape of sealing curtains for each specific case basing on which

the grouting technique is specified.

To select the design method, the critical quantity of fissure opening is determined at which the formation of a sealing curtain still is proceeding in the pressure regime without grout dislocation on-dip.

During grout propagation in a water-bearing, inclined heading the sealing curtain with an ellipse-like shape is being formed, as it is shown in Fig.1, where R_{max} - maximum radius at $\varphi = 0$ and $\cos\varphi = 1$; R_{min} - minimum radius at $\varphi = \pi$ and $\cos\varphi = 1$; R - normal radius at $\varphi = \frac{\pi}{2} = 3\frac{\pi}{2}$ and $\cos\varphi = 0$.

The character of changing of radius R_k together with the thickness and mine working location will determine the shape and, thus, the volume of a sealing curtain.

With regard to the thickness of a mine working and optimum grout propagation radii R_k, the spacing and number of grout holes drilled from the surface are determined.

INTRODUCTION OF DEVELOPMENTS

The presented developments were applicated at ventilating shafts No.2 and No.3 of Yuzhnaya mine. The shafts have finished diameter of 6 m, and are 668 and 665 m deep. The shaft lining is a monolithic concrete 300 mm thick, and 500 mm thick in the zones of faulted rock with flexible belts in each 10 m.

The shafts No.2 and No.3 intersect the worked-out coal seam K_2^1 at depths 211.2 and 208.0 m correspondingly. The elimination of Nezhdannaya mine and its flooding resulted in the need to protect the shafts from water makes in the worked-out seam. In the shaft site the coal seam K_2^1 was mined out during 1945-1948. The average thickness of the seam was 1.8 metres. The roof of the face includes a 1.0 m thick limestone and overlaying clay shales, sandy shales and sandstones.

During coal seam mining the worked-out space had been partly back filled with rock, after which in the course of time the working's roof subsided. The average thickness of open underground voids in the old face was determined to be from 0.5 to 1,2 m. Theses data were obtained from survey borehole drilling in the course of design activities.

In accordance with the grouting project the worked-out face was treated via 13 boreholes in the shaft No.2 and via 15 boreholes in the shaft No.3. These boreholes were drilled from the ground surface and spaced around the mine shafts as it is shown in Fig.1.

The characteristics of treated zones are enlisted in Table 1.

The grouting curtain for each above mentioned intervals has been calculated with regard to a maximum hydrostatic pressure after flooding equal to 2.0 MPa. The required designed volume of grout for shafts No.2 and No.3 amounted 19190 m^3 and 19930 m^3 correspondingly.

The grout holes had the following design:

- in the range of 0-50 m they were drilled with a diameter of 214 mm and cased with 168 mm dia. pipes, in the range of 50-225 m they were drilled with a diameter of 132 mm and cased with 108 mm pipes. To provide grout injection into specified zones, the hole casing was perforated by a jet perforator.

In the course of drilling hydrodynamic and geophysical investigations were carried out in grout holes to determine more accurately the parameters of grouting. The size of the intersected mine working was more accurately defined using IBAK downhole TV equipment.

The parameters of the sealing curtain around shafts No.2 and No.3 along the worked-out face (Fig.2) were controlled by means of an acoustic downhole sounding.

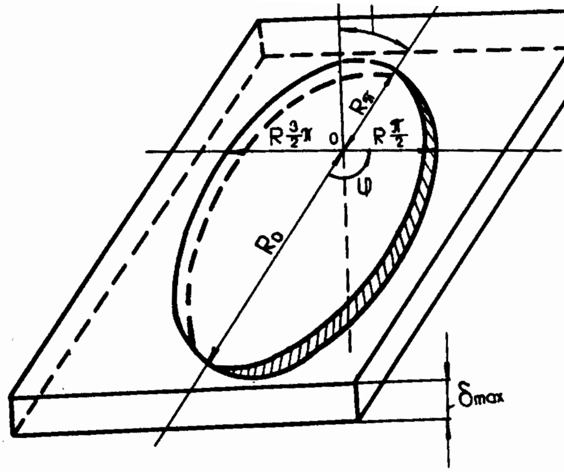

Fig. 1 Sealing curtain formation diagram for gently dipping mine excavation

Table 1

Grouting interval	Shaft No.2			Shaft No.3		
	Depth range, m	Thickness, m	Voidage 10^{-2}	Depth range, m	Thickness, m	Voidage 10^{-2}
Fissured rock interval	157.2-186.2	29.0	1.0	155.4-184.9	29.0	1.0
Increased rock fissuring interval	186.2-203.7	17.5	2.0	184.4-201.9	17.5	2.0
Intensive rock fissuring interval	203.7-210.7	7.0	5.0	201.9-208.9	7.0	5.0
Worked-out interval	210.7-211.2	0.5	100.0	208.9-209.4	0.5	100.0
Discharge zone	211.2-216.2	5.0	1.0	209.4-214.4	5.0	1.0

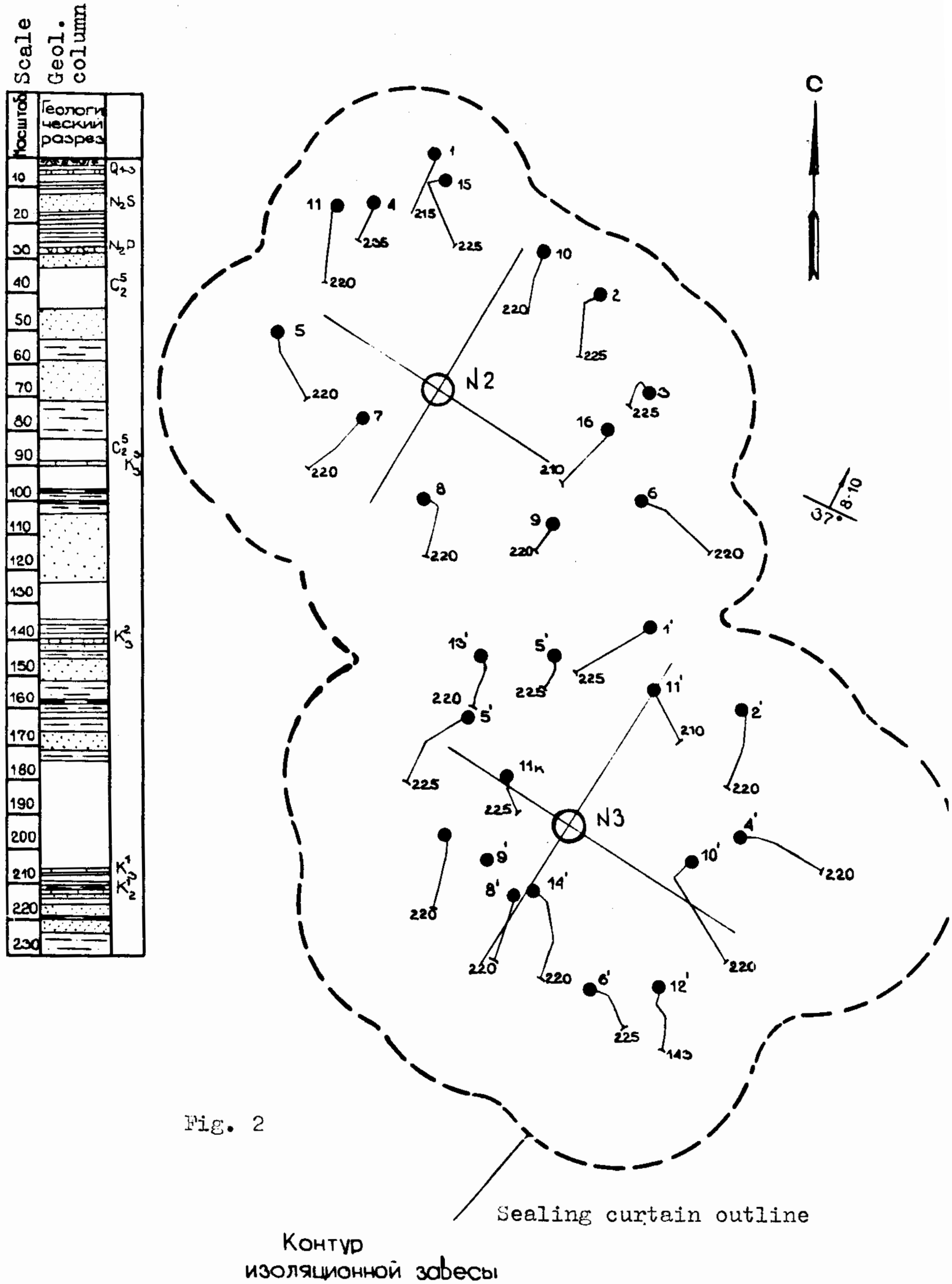
Scale
Geol. column
Масштаб
Геологический разрез
N2
N3
С
Sealing curtain outline
Контур
изоляционной завесы

Fig. 2

RESULTS

On completion of grouting operations the old mine workings of Nezhdannaya mine were flooded. There are no water makes in the shafts of Yuzhnaya mine that prooves the reliability of the designed grouting programme for old workings using clay-cement grouts.

According to the accomplished estimations the cost of grouting will be covered in 8 years due to eliminating the need for pumping and electric power expenditure. Taking into account the term of mine shaft operation of 60 years, the cost saving thanks to grouting becomes rather sufficient.