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GROUTING OF OLD FLOODED WORKINGS AT M. MAYEROVA MINE IN CZECHOSLOVAKIA

E.Ja. Kipko, Yu.N. Spichak, Yu.A. Polozov, A.E. Kipko,
P/A Spetstamponazhgeologia, 349240, Antratsit,
7a Petrovski St., Lugansk Region, Ukaraine.

and
P. Hepnar
Geoindustria-Geological Service, Pristarni, 24,
17000 Praha, Czechoslovakia

ABSTRACT

The paper is concerned with the design of a surface mining operation above a water-logged underground mine workings in order to prevent ingress of water and control mine water pollution. The site of investigation was situated at M. Mayerova Mine, near the city of Karlovy Vary, Western Czechoslovakia which was operational at the end of 19th century. These mine workings were abandoned and subsequently, presented the a problem of eliminating flooded mine workings encountered in Jozef Seam at a depth of 176 m and two 4 m. diameter, No. 2 and No. 5, vertical mine shafts. The proposed mining operations were planned to extract overlying Antonin Seam at a depth of 88 m.below the surface by open casting technique and to prevent ingress of water into the planned workings.

This problem had been complicated by a hydraulic connection of flooded workings of the Jozef Seam, recharged from the intersected fault zone, with regional reserves of mineral thermal springs of the city of Karlovy Vary through fissured sandstones and quartzites underlying the coal layer.

For resolving the problem and in accordance with the project report and methodology of Integrated Grouting Technique of P/A Spetstamponazhgeologia (STG), Geoindustria Enterprise, Czechoslovakia has conducted injection of the designed volume of clay-cement grout into the flooded workings. The grout was pumped through surface drilled boreholes under specified regimes. As a result, the inflow to the Jozef seam workings was reduced from 0.5 m^3/min to 0.0002 m^3/min, ground water temperature fell down from 31°C to 18°C. The paper deals with the actual data of this original project.

SITE GEOLOGY

Terrigenous strata of the site under consideration comprises two working brown coal seams (the Antonin and Jozef seams) interbedded with sandy-clay layers. The Antonin

coal seam is encountered in the depth of 88-127 m and has an overall thickness of up to 30 m. The Jozef coal seam is bedding in the interval of 176 -185 m and was opened by the two vertical shafts No. 2 and No. 5 at M. Mayerova Mine and by the system of development workings.

The No. 2 and No. 5 shafts are 4.0 m in finished diameter and are lined with brickwall lining to the total depth. The size of the Jozef seam workings is 2.5 × 2.0 m with a cross-section of 5-6 m^2. Mine development in the Jozef seam was stopped after the water inrush with a discharge of 100 m^3/hr from the underlying layer of water-bearing sandstone and quartzite. The water inrush resulted in the flooding of development workings and shafts No. 2 and No. 5 to the levels of the Antonin seam.

A two-stage sealing plug was constructed in the shaft No. 2 below mining operations of the Antonin seam at an absolute level +315 m. The vertical shaft No. 5 was filled with crushed rock up to the level of the Antonin seam. The shaft served as a discharge path for ground water coming from the Jozef seam.

GROUT SOLUTIONS

It was necessary to develop cost-effective and efficient grout compositions based upon locally available native clay to reliably seal the flooded workings in the Jozef seam. The grout had to feature the following requirements:

- ecological cleanliness,
- presence of stable rheological properties,
- sharp increase of strength on the cessation of their injection and feed into the flooded workings,
- 100% yield of solid grout material,
- high corrosion resistance against mineralized ground water impact within the total operational period of the pit.

GROUND WATER PROTECTION PROBLEMS IN THE AREA OF KARLOVY VARY

In view of the planned abandonment of M. Mayerova Mine, Sokolovasky Coal Basin by 1992 and transition to mining the Antonin coal seam by open casting, there arose a number of problems dictated by the potential of ground water ingress to a future pit from the flooded abandoned workings in the lower Jozef coal seam. From one hand, the ingress of highly mineralized water to the future pit lead to the slide of pit walls, pit inundation and necessitate the installation of an in-pit pumping system.

From the other hand, there is a danger to strongly affect on hydrodynamic balance of ground and thermal waters in the area of a would-be pit. The latter will be inacted by a hydraulic connection of the flooded workings in the Jozef seam with the thermal spas of the Karlovy Vary resort. This is confirmed by the identical mineralogical content of the waters. As appears from the above, open pit mining of the Antonin coal seam under protection of a depression cone may lead to depletion of regional resources of thermal spas.

Moreover, the discharge of highly mineralized water may lead to the degradation of adjacent ponds and soil salinization.

The next problem is associated with the probability of rock strata deformation during mining activities due to high load applied by the pit transport vehicles, on the pit bottom which is underlain by ungoafed development workings in the Jozef Seam.

With the aim to preclude the expected problems STG had signed a contract with Geoindustria Enterprise, Ozechoslovakia to prepare project report and refine technology on grouting old flooded workings in the Jozef Seam of M. Mayerova Mine. This entailed the formulation of clay-cement corrosion-resistant grouts based upon native materials.

- o good adhesion of the encountered rock,
- o low content of cement

Laboratory studies with regard for hydrodynamic and water chemistry conditions of the grouting environment, assessment of structural-mechanical and rheological properties of the grouting material resulted in the formulation of a visco-plastic clay-cement grout consisting of local loam by 90%, cement by 8% and structure-formation reagent by 2%.

Special attention during grout formulation process has been attributed to its corrosion resistance X-ray spectrography tests confirmed high resistance to corrosion of the developed grout material that allowed reliable sealing of workings in the Jozef seam to be guaranteed in highly mineralized water environment and within the total operational period of the pit.

GROUTING PROGRAM DESIGN

In accordance with actual hydrogeological conditions STG, applying their methodology, conducted engineering analysis of the process of sealing the flooded workings and host rock. This covered calculated parameters from the number of grout holes and clay-cement grout propagation radius up to the volumes and regimes of grout injection, to the 3 following sites:

I - ground water inrush zone from a tectonic dislocation into development workings of the Jozef seam,

II - horizontal development workings of the Jozef seam,

III - vertical shafts No 2 and No 5 up to the level of the Antonin seam.

The fissuring parameters of encountered rock strata, ground water pressure, head, cross-section and size of vertical and horizontal workings, grout properties were taken into account during design phase. As a result, the grouting program on sealing the flooded workings was designed to be implemented through 14 vertical and 4 inclined boreholes (Figure 1) by injecting 8200 m^3 of clay-cement grout.

Design parameters of the grouting program for M. Mayerova Mine are enlisted in Table 1.

TECHNOLOGY OF GROUTING OPERATIONS

The preparation and injection of clay-cement grout were performed by the cementation equipment used in oil drilling industry. Clay slurry with the specified viscosity and density was prepared at the first stage by cutter-blade mixers at a volume of 100-150 m^3/day. Clay-cement slurry of the designed volume was prepared and injected at the second stage.

The boreholes No. 17 and No. 18 were first drilled to a total depth of 215 m (Figure 1). The program of hydrodynamic and geophisical testing resulted in establishing the occurrence of a direct hydraulic connection between the boreholes and mining workings of the Jozef seam. The latter circumstance stipulate the increase of grout

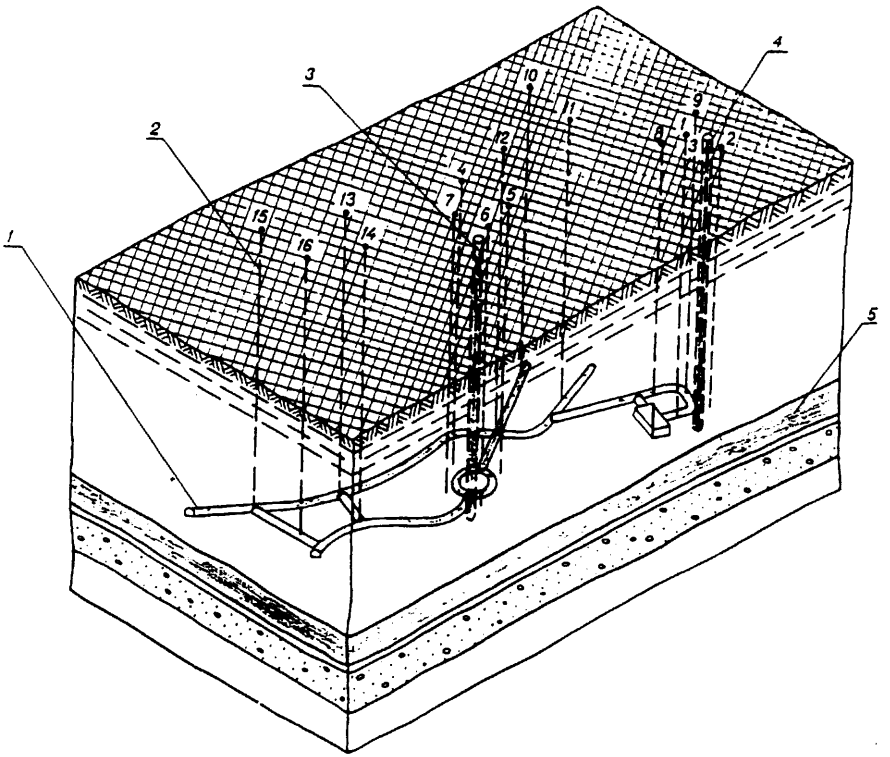

Figure 1. Grouting Program Scheme at M. Mayerova Coal Mine, Czechoslovakia
1. - Old Mine Workings, 2 - Grout Injection Holes, 3 - Shaft No. 5, 4 - Shaft No. 2, 5 - Jozef Coal Seam

injection volume to the borehole No 17 and No 18 up to 1001 m^3 for sealing the broken rock in the inrush zone and adjacent strata of old workings.

Taking the account of the above mentioned, the volumes of grout injection to other boreholes were revised. The vertical holes No 1-3 for sealing the vertical shaft No 5 and inclined boreholes No 4-7 for sealing the vertical shaft No 2 were then drilled and grout injected with 1253 m^3 and 862 m^3 respectively. Finally, grouting of horizontal workings in the Jozef seam was performed through the vertical boreholes No. 8-10 and 12-16.

Table 1. Design Parameters of the Grouting Program for M. Mayerova Mine

No. Borehole Target	Number of Grout Boreholes	Borehole Depth, m	Borehole Type	Grout Injection Volume, m^3
1. Grouting of the inrush zone of the Jozef Seam	2	215	vertical	540
2. Grouting of horizontal workings in the Jozef Seam	9	200	vertical	5380
. Grouting of the vertical shaft No. 5	3		vertical	1160
4. Grouting of the vertical shaft No. 2	4		inclined	1120
Total	18			8200

The alteration of designed regimes and grout injection volumes resulted in eliminating the need for drilling borehole No. 11.

The actual grout injection volumes in relation to the flooded workings, shaft No. 2 and shaft No. 5 and inrush zone are enlisted in Table 2.

Table 2

No Borehole Target	Borehole No	Grout Injection Volume m^3
Grouting of inrush zone in the Jozef seam	17-18	1001
2. Grouting of flooded mine workings in the Jozef seam	8-12/ 13-16	4932
3.1 Vertical Shaft No 5 Grouting	1-3	1253
3.2 Vertical Shaft No 2 Grouting	4-7	863
Total		8049

GROUTING PROGRAM QUALITY CONTROL

Monitoring of the following items was being undertaken to assess the efficiency of grouting operations at M. Mayerova Mine:

- initial clay slurry parameters (density, conventional viscosity, static shear strength),
- grout injection technological regimes (density, flow rate and injection pressure, quantity),
- grout spread process in vertical and development workings.

The process of grouting in the inrush and flooded workings zones was simultaneously controlled:

- by the reduction of permeability of the encountered rock strata and by flowmeter tests in grouting boreholes prior and after grout injection,
- by achieving the final designed regimes of grout injection,
- by measuring the reduction of ground water temperature.

The analysis of quality control procedures has proved high efficiency and reliability of the grouting program for M. Mayerova Mine.

CONCLUSIONS

The grouting program on treatment of the inrush zone and flooded workings at M. Mayerova Mine resulted in the decrease of inflow from 0.5 m^3/min to 0.0002 m^3/min, or by 2500 times.

The ground water temperature was reduced from 31°C to 18°C that proves the reliable sealing of mine water from thermal spas, contributes to the preservation of their resources and prevents the contamination of balneological water. The grouting technique described above may be successfully applied at the mercury mine Idriya, Slovenija.