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INTEGRATED GROUTING METHOD ON KARSTIC ROCK ISOLATION IN DOBROGEA COAL FIELD

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ABSTRACT

The Dobrogea coal field in Bulgaria is one of the most complex mining areas in the world: mine shaft depths will be 2000 m; the anticipated water inflows are about 8 m/s; and the cavity size in water-bearing strata amounts to 3m or more. To obtain the information for projecting a grouting program, the specialized association "Spetstamponazhgeologia" worked out the project of hydrodynamic investigation, supplied instruments and rendered methodical assistance in carrying out the project. At present time experimental grouting of the most watered strata is completed and water inflows are reduced nearly 3.000 times.

Until recently, exploitation of the Dobrogea coal field in Bulgaria was impossible for lack of methods of controlling catastrophic water inflows in sinking 2000 m deep shafts.

The Valange formation presents most of the difficulties for sinking. This formation is located in the interval of 700-1400 metres and consists of a thick series of cavermous limestone and dolomite strata with cavities ranging up to 3 m and more, and with underground water flow rate of up to 5.0^{-3} m/s. The anticipated water inflow totals about 8 m/s, and strata pressure is 12 MPa.

Traditional methods of controlling water cannot produce good results because when injecting cement, chemical and other grouts, they are washed out before setting takes place; methods of freezing are applicable only when the underground water flow rate is not more than $0.1 \cdot 10^{-3}$ m/s.

To settle the problem of controlling water inflows, the Soviet production association "Spetstamponazhgeologia"

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was enlisted to work out the project of hydrodynamic investigation, supply the necessary instruments and equipment and render methodical assistance in carrying out the project. The hydrodynamic investigation program helped to obtain data to be used for the experimental grouting project of the most watered strata of the Valange formation.

The object of the experimental grouting is to determine the possibility of isolating certain formations within those that are the most characteristic in their hydrodynamic properties and intervals of the Valange. Another objective is to prove on industrial scale the developed methods of projecting and technological patterns of cavernous rock grouting, the effectiveness of mud-cement slurries and methods of quality control of grouting.

Hydrodynamic testing was accomplished in the course of drilling after every 50 metres with the help of flowmeters "DAU-3M" type and packers of the "DAU-I" type.

Each interval was tested at 2-3 drawdown rates while pumping and at 2-3 rates of injecting with constant flow. Upon completion of a testing, pumping /injection/ was stopped and the process of pressure recovery was fixed by the electric level-meter. Following this, the next rate testing was started. During testing it was necessary to place the packer and to run the flowmeter only once.

Such technological process schemes allow to test selectively water-bearing strata without casing and to obtain comprehensive hydrogeological information: underground water head; filtration and permeability factors; cavity voidness; place of occurence, number, orientation and size of cavities.

The completed hydrodynamic investigation program was accomplished for the first time with such degree and scale of detailing at the Dobrogea coal field.

The program of testing ascertained that the most permeable zone is in the interval 840.6-933 m with a permeability factor $5.2\text{-}6.4 \cdot 10^{-12}$ m² and rock voidness of 28.1 %.

Cavity size is in the range of 2.7-3.3 m. The anticipated water inflow is 2.7 m³/s. In the upper and bottom strata of the Valange formation water abundance sharply decreases.

Data obtained in the course of testing were the basis for working out the experimental grouting project of the most watered strata of the Valange formation.

This project envisages a program of grouting in some of the most characteristic zones which are presented by strata where intensive comparatively evenly-distributed fissuring is located. These are the 855-885 m, 885-902 m,

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902-924 m zones.

Monitoring the process, both grouting and quality control is carried out by the control station "SkTs-2M".

In the course of laboratory tests for the Dobrogea project, grout compositions were developed and structural-mechanical and rheological characteristics were determined.

Being rather thick and highly penetrating, these grouts are not washed out by underground water, do not produce sediment and remain pumpable while flowing through the pipes and fractures, but gain strength rapidly when at rest. Blasting operations in sinking or driving only make them more compact.

The above positive properties ensure reliability of water-isolating curtains during the whole mine production period. On the other hand, using cement slurries, water inflows tend to increase after a short period of time which necessitates postgrouting operations.

Grouting program and quality control of grouting are carried out in the following sequence:

1. The grout is injected through a high-pressure line.

2. During the course of grouting, injection process parameters are controlled. In line with grouting operations, analytical calculations and actual quality control of grouting results are accomplished.

3. Grout injection is completed when the calculated value of injection pressure is reached. The next operation is placing the second packer within the high-pressure line 10-15 metres above the main packer. The smaller diameter packer is run down the hole on drilling tubes having 0.05-0.063 m out. dia. Then injection of additional grout volume is accomplished to seal fine fractures and to provide the calculated value of residual permeability.

4. Upon completion of grouting, the hole is left for five days for the grout to gain strength. After this, the inner packer is dismounted and redrilling is carried out.

5.Hydrodynamic investigation program is accomplished at 3 rates of pumping with flowmetering and pressure recovery testing.

6. Experimental grouting is finalized by interpreting the obtained results.

At present, experimental grouting is completed of the most watered strata of the Valange formation in the interval

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of 902-924 m. Grouting operations produced excellent results as the water inflows were reduced nearly 3.000 times.

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