Filling-up mine spaces of »Block 1« and »Block 2« in the Uranium mine Žirovski vrh from the surface and remediation of a damaged cementation of well for filling-up mine spaces

Zapolnjevanje jamskih prostorov bloka 1 in 2 rudnika urana Žirovski vrh iz površine in sanacija poškodovane cementacije vrtine za zapolnjevanje jamskih prostorov

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Abstract: Due to the closure of uranium mine Žirovski vrh maintenance of mining spaces have been abandoned. Abandoning of maintenance consequently brought to abetment of supporting measures which resulted in widening of the destruction processes around excavated areas. In the case of uranium mine Žirovski vrh radiological contamination of the area above excavated spaces of blocks 1 and 2 could appear through cracks. Idea about filling up isolated places with the filling concrete which could be poured into the mine through drills, made from the surface, has emerged. For filling up excavated spaces in blocks 1 and 2 of uranium mine Žirovski vrh 11 wells have been made for integrating filling concrete in open mine spaces. During the fill-up of mine spaces with the filling concrete in block 2 an increased inflow of water from upper layers into the mine was discovered. The article presents realization of wells for filling up excavated areas, the process of filling up itself and the procedure of remediation of a damaged part of the well's cementation.

Izvleček: Zaradi zapiranja rudnika urana Žirovski vrh je bilo opuščeno vzdrževanje jamskih prostorov. Opustitev vzdrževanja ima za posledico popuščanje podpornih ukrepov, kar posledično vodi do širjenja rušnih procesov okoli odkopanih prostorov. S časom se zlasti v primeru nizkega nadkritja pojavijo deformacije površine nad odkopanimi prostori. V primeru rudnika urana Žirovski vrh bi preko razpok, ki se tvorijo v toku napredovanja rušnih procesov, prišlo do radiološke kontaminacije območja nad

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odkopanimi prostori blokov 1 in 2 rudnika urana Žirovski vrh. Kot ideja se je ponudilo izvajanje zapolnjevanja izoliranih prostorov s polnilnim betonom, ki bi se ga v jamo zapolnjevalo preko vrtin izdelanih iz površine. Za zapolnjevanje odkopanih prostorov blokov 1 in 2 rudnika urana Žirovski vrh je bilo izdelanih 11 vrtin, skozi katere se je vgrajevalo polnilni beton v odprte jamske prostore. Tekom zapolnjevanja jamskih prostorov s polnilnim betonom je bil na eni izmed vrtin v bloku 2 ugotovljen povečan dotok vode iz zgornjih plasti v jamo. V članku bo predstavljena izvedba vrtin za zapolnjevanje odkopanih prostorov, zasipavanje samo in postopek sanacije poškodovanega dela cementacije vrtine.

Key words: injecting, well, remediation, drilling, cement suspension
Ključne besede: injektiranje, vrtina, sanacija, vrtanje, cementna suspenzija

INTRODUCTION

Due to the way how the excavated mine spaces were closed-out in the end of 1980s of the previous century, blocks 1 and 2 remained isolated. Long-term isolation of the area and top to bottom winning method triggered a destructive process which has advanced towards the surface. Due to demolished excavations and partially removed ore and consequent radiation, the usual way of closing down mining sites by filling them up from the inside was not possible.

We came up with an idea of performing the filling of isolated sites by the usage of filling concrete which could be brought into mine openings through wells made from the surface. For the purpose of filling-up excavated parts of blocks 1 and 2 in the uranium mine Žirovski vrh 11 wells have been drilled and used for integrating filling concrete into open mine spaces. At first 8 wells were made and filling of the block 1 was realized, so it was possible to check efficiency of the projected method. It was ascertained that the method is usable since the level of the fill-up of the mine space was sufficiently high comparing to the filling-up done inside the mine. Due to positive experiences another three wells were made in the area of block 2.

Creation of wells for filling up openings in block 1 and 2

Creation of wells took place with a percussion rotational method using DTH hammers and compressed air. For the case of troubles which were expected in »Jazbeška luska« area another option of drilling with rolling bits and drilling mud with addition of bentonite had been anticipated.

Before starting with works a geodetic situation of the area had been well investigated using mining maps. Wells were positioned above areas which enabled as high level of filling-up openings as possible. In order to cut drilling costs all of the wells were projected with the same drilling parameters. Wells construction was as follows:

Column	Well	Tubing
Introduction column	∅ 584.2 mm (23")	Ø 508 × 6.3 mm (St37, weight = 77.9 kg/m)
Technical column	∅ 311.1 mm (12 ¼")	∅ 244 × 6.3 mm (St37, weight = 77.9 kg/m)
Reserve profile	∅ 431.8 mm (17")	∅ 355.6 × 6.3 mm (St37, weight = 54.3 kg/m)

Due to our presumption that »Jazbeška luska« will cause problems in the course of drilling, extra »reserve profile«, which could be used in case of a need, was added to the construction of the drill.

Cementation of the column

For additional stabilization of the well the columns were cemented. Cementation took place in accordance to Perkins – i.e. cementation through the tubes into the inter-space using separation fluids or caps. For cementing a cap in the inter-space a cementation basket was used.

PREPARATION OF FILLING CONCRETE, TRANSPORTATION AND TECHNOLOGY OF FILLING EXCAVATION SPACES THROUGH WELLS

Preparation of mine spaces for filling

Before the filling and stabilization of open mine spaces in blocks 1 and 2 started, it had been necessary to create ferroconcrete barricades around those two blocks in order to prevent the possibility of uncontrolled pouring of the filling concrete out of the area of former openings of the block 1 and 2.

Filling concrete preparation

Filling concrete was mixed in an existent concrete plant which was situated in the area of Jazbec, i.e. P-11. According to the data about the size of the openings it was estimated that it would take around 40.000 m^3 of the filling concrete in order to fill-up all open spaces in the area of block 1 and 2. For filling concrete preparation the following ingredients were used:

- Sifted mining tailings, fraction 0/10 mm (gray flint sandstone)
- Electrofilter ashes from the steam power station Šoštanj
- Cement CEM II 42,5 N
- Chemical additives – retarder and aerant
- Water

For 1 m^3 of the filling concrete 180 kg of cement, and 240 kg of ashes was used, the rest was composed of sifted mining tailings 0/10 mm and water. This recipe was tested in October 2003 in the ZJ 10/11 shaft. Aggregate 0/10 mm showed acceptable properties in prepared filling concrete.

Transportation of the filling concrete

Transportation of the filling concrete was carried out with concrete-mixing trucks. Influx of the well was equipped with a pouring funnel through which the concrete was poured-in. Special care was taken because of the danger of cap creation. Owing to advanced technology this did not happen. For just in case a drilling set of machinery was prepared so it would have been possible to pierce an eventual cap.

Filling-up with filling concrete through wells commenced on wells, located on the edges of excavated fields of the block 1 and 2. After completing outermost edges of the fields further filling through wells, located in the central part of former excavating fields continued. Filling of each well was finished when it was completely stuffed with filling concrete right to the top.

Inspection of filling concretes

At fresh filling concretes it was necessary to control quality of its making. This procedure included the following:

- Inspection of ingredients of the filling concrete (aggregate, cement, water and additives to the filling concrete (retarder and aerant));
- Inspection of fresh mixture of the filling concrete (temperature, water-cement factor W/C, consistency, containment of cement and containment of micro-pores);
- Examination of pressure solidity.

Remediation of well places

When the works were finished, drilling and filling places, including working plateau and access road, were restored into their original states.

CONCLUSION OF FILL-UPS OF BLOCK 1 AND 2 EXCAVATED PLACES

During the fill-up of mine spaces the quality and quantity of the filling were constantly examined. It was concluded that places were filled with quality because the quantity of the filling was regularly controlled by observations made through the wells (using a camera) and from controlling points inside mine.

Quality of the material actually used and predicted before was within 5 % deviation. Less concrete was used than planned.

PROBLEMS WITH THE V-2/3 WELL

Few weeks after the well V-2/3 was accomplished the water inflow of the barrage near Laz dried up. This spring is provided with water from »Jazbeška luska«. And at the same an increased inflow of mine water on the purifying plant was detected. It was established that the inflow of water in the area of the V-2/3 well increased. The well was inspected by the camera. Established and confirmed was an increased inflow of the water at the outside wall of the protecting column of the well.

Due to the technology used in drilling (percussion rotational method) which

resulted in creation of vertical and horizontal cracks around the well, water from the »Jazbeška luska« area changed its course and started to pour into the mine.

Increased flow of water from »Jazbeška luska« into the mine resulted in additional leaching of the uranium from open mine corpuses in blocks 1 and 2 which brought to increased contamination on the exit of the mine. Increased inflow of suspended particles could mean additional burden for the purifying plant which should assure cleaning of the water, flown from the mine. In eventual raining period the inflow of the water could reach a level at which it could not get cleaned enough. Our additional desire was to re-establish levels of clean water in the barrage of Laz which provides nearby farm with drinking water. Due to this fact it was necessary to find a technical solution which would divert water flow away from the V-2/3 area.

Geological situation in the V-2/3 well area

In the area of the drilling filling wells above demolished parts of the ramparts in block 1 and 2 we found ourselves in inverted wing of the upper fault in double-faulted structure of Žirovski vrh which is typical for this part of the mining zone. Under the surface there is a layer of decayed material (clayed lateral rubble) and highly decayed rockery. According to the data from surface wells thickness of this layer above block 2 is between 7 and 10 m.

Under the decayed layer there are sandy and silt aggregates of different thicknesses, subordinately conglomerates can occur as well. All listed rockeries, particularly sandstones and conglomerates contain high percentage of flint which makes incline very abrasive. Layers lie in inversed positions and their angle of incidence is from 30 to 70 ° facing north-east i.e. they slope down-hill. Slate nature of the rockery which is most obvious in finely grained rockery inclines in the same direction.

Most important among tectonic characteristics is presence of pile zone of »Jazbeška luska« which occurs mostly in the area of the longitudinal profile 1000, 34 to 58 m deep. Its depth on the spot of V-2/3 well is 35 to 38 m. Aside the pile zone the rockery is crushed, inside the tectonic clay occurs which makes pile zone an impermeable layer. Above the pile zone hanging underground water occurs which makes water inflows more likely.

Determination of crack closings around V-2/3 well

In IRGO Ljubljana we decided to carry out crack closings around V-2/3 by injection of the surrounding. Injection had to be performed in the entire area of »Jazbeška luska« with special attention on the spot where loss of the drilling mud was noticed when the V-2/3 well was drilled.

After exact study of diaries and notes, written during the drill of the V-2/3 well the composition of the well was determined and can be found in Table 1.

Table 1. Diameters of drilling and well tubing of the V-2/3 well by separate sections
Tabela 1. Premeri vrtanja in cevitve vrtine V-2/3 po posameznih odsekih

Depth	Type and diameter of the drilling tool	Diameter of tubes
0 – 17.8 m	Rolling chisel D = 660.4 mm (26")	Steel tube D = 508 × 6.3 mm
17.8 m – 57 m	Rolling chisel D = 444.5 mm (17 1/2")	Steel tube D = 355 × 6.3 mm
57 m – 110.5 m	Rolling chisel D = 311.1 mm (12 1/4")	Steel tube D = 244 × 6.3 mm

Ascertained losses of the rinsing media are given in Table 2.

Table 2. Losses of the rinsing media
Tabela 2. Izgube izplačnega medija

Section	Lost quantity of the rinse
35 m	30 m^3
36 – 38 m	30 m^3
49 – 50 m	20 m^3
58 m	20 m^3
72 – 78 m	60 m^3
Total:	160 m^3

According to the data about geology, direction of the underground water stream and factors of the drilling it was determined that injecting of the well V-2/3 area with two 58 m deep injecting wells will be carried out. The injecting will be performed in phases with a cement suspension MB25 and WC=0,4.

Implementation of drilling and injection

Drilling injecting wells

Drilling of injection wells was implemented in striking-rotational manner using depth hammers and compressed air. The performer of the drilling and injecting works was ROVS d.o.o. from Ljubljana. Arrangement of injecting wells is shown in Figure 1.

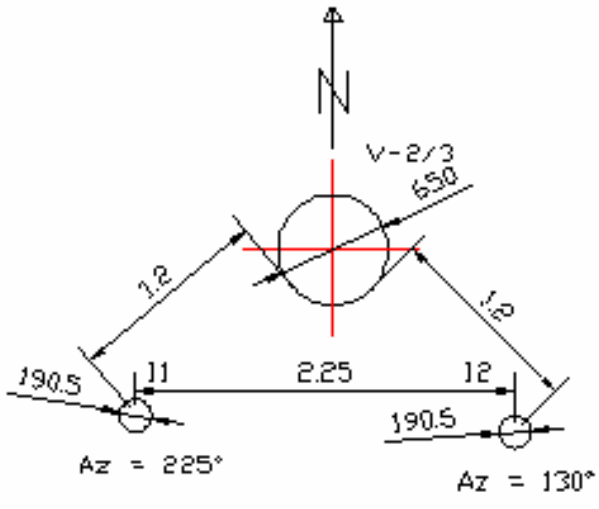

Figure 1. Arrangement of injecting wells
Slika 1. Razporeditev injekcijskih vrtin

Construction of an injection well

- **Introduction column**

Up to 20 m an introduction column was implemented in order to prevent losses of the cement suspension and consequently pressure drop in upper decayed zone. Drilling of the introduction column was carried out with the drilling tool Ø 190.5 mm (7 ½").

In the well a steel tube Ø 168.3 × 4 mm (6 5/8") was built-it. Junctions among tubes were welded using electro-welding. The tube of the introduction column had to be quality cemented. Cementation was done according to Perkinson method. Influx of the introduction column was equipped with a flange, a manometer for controlling pressure and a valve.

- **Technical column**

From the depth of 20 m to the anticipated final depth of 58 m, the well was drilled using a drilling tool ∅ 114.3 mm (4 ½"). During the drilling of the first injection well presence of a geologist, who defined the final depth of the wells was assured. Tubing of the technical column was not necessary.

During the drilling process it was necessary to follow losses and interruptions of the circulation of the rinsing media. In particular it was necessary to be careful about sections where losses of the rinsing media occurred during the drilling of the V-2/3 well. Construction of the injection well is shown on Figure 2.

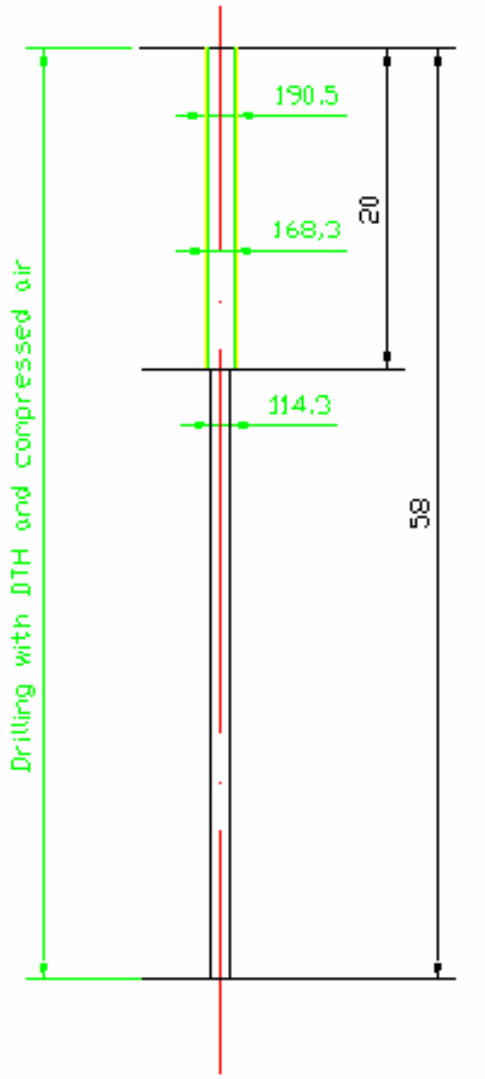

Figure 2. Construction of the injection well
Slika 2. Konstrukcija injekcijske vrtine

Injection

Before the injection begun it was necessary to carry out a pouring test in order to determine permeability of the layer. This test showed the speed of injection mass sinking and thus determined times needed for preparation and supplying of the mass into the well as well as confirmed and disclosed required changes in the recipe for cement suspension. Injecting with cement suspension MB25 and WC=0,4 was anticipated.

Pouring tests showed that the permeability of the layer is very low so we had to adapt the recipe for cement suspension. WC factor was increased to 1.3. Because of this the final solidness of the cement suspension was decreased which turned not to be very important in the end, but we gained better dispersion in the layer and penetration into micro-cracks.

Inflow of the suspension was assured through temporary tubing on the bottom of the well. Owing to the over-pressure the cement suspension poured gravitationally on the bottom of the well with no extra help of a pump. Injection of the surrounding of the well was performed through both injecting wells simultaneously in two phases, first phase on the depth of around 38 m and the other on 58 m. In both wells around 75 m^3 of the cement suspension was built-in.

Injection efficiency

After the end of phase one of the injection on depths of about 38 m, the V-2/3 well was inspected with a camera. Reduction of the water income from the outside of the well was discovered. At the end of the second phase of the injecting the V-2/3 well was re-inspected with a camera. The water income was discovered to be ceased. After some time water in »V Lazu« barrage reemerged which brought us to conclusion that the V-2/3 remediation was successfully carried out.

CONCLUSONS

At the reconstruction of the V-2/3 well it can be concluded that all conditions, needed for a quality realization of works was met. Conditions, needed for quality realization of works are:

- good knowing of the problems;
- very good familiarity of geological circumstances in the area of the well;
- quality metrical data of the mine with a connection to the surface;
- good knowledge of used technologies;
- good workmanship;
- good cooperation between the projecting engineer and executants of the works.

Remediation was well implemented and carried out with minimal expenses.

POVZETKI

Zapolnjevanje jamskih prostorov bloka 1 in 2 rudnika urana Žirovski vrh iz površine in sanacija poškodovane cementacije vrtine za zapolnjevanje jamskih prostorov

Ob izvedeni sanaciji vrtine V-2/3 lahko ugotovimo, da so bili izpolnjeni vsi pogoji, ki so potrebni za kvalitetno izvedbo del. Pogoji potrebni za kvalitetno izvajanje del so:

- dobro poznavanje problematike;
- zelo dobro poznavanje geoloških razmer na območju vrtine;
- kvalitetni jamomerski podatki s površinsko navezavo;
- dobro poznavanje tehnologije po kateri se dela izvajajo;
- kvaliteten projekt za izvajanje del;
- kvaliteten izvajalec del;

- dobra sodelovanje med projektantom in izvajalcem.

Sanacija je bila izvedena kvalitetno z minimalnimi stroški.

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