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ЦИМЕНТИРАНЕ НА ПУКНАТИНИ ПОД БЕТОНОВИЯ КРЕПЕЖ В ГАЛЕРИЯ КИНГА НА СОЛНА МИНА ВЕЛИЧКА

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РЕЗЮМЕ
Дългогодишният добив в мина Величка е довел до оттичане на пресни води с различна интензивност към солните формации зад излужените каверни в солния масив. Разглежда се техническият риск в солна мина Величка като се отделя специално внимание на бетоновия крепеж в галерия Кинга, както и на нарушените геоложки, хидрогеоложки и минно-технически условия в близост до галерията. Описан е инжекционен метод, използван за подобряване на якостните характеристики на бетоновият крепеж и за циментиране на вместващите солни формации.

ВЪВЕДЕНИЕ

Инженерно-техническите характеристики на бетонните конструкции, и по-специално на крепежа на минните изработки са факторите, които ограничават правилното и икономически изгодно изпълнение на циментирането по сондажно-инжекционен метод.

Целта на инжекционните работи в бетоновия крепеж на минните изработки е следната:

- -директно подобряване на физикохимичните свойства на крепежа;
- понижаване водопропускливостта на крепежа;

Всички нарушения на физическата цялост на бетонния крепеж, изработката имат съществено значение за водопропускливостта.

Нарушенията на физическата цялост могат да образуват сложна мрежа от пукнатини, която се характеризира с множество свойства, т.н. свойствата са пукнатините, а именно:

- пространствена ориентация на пукнатините;
- линеен размер на пукнатините;
- степен на напуканост;
- степен на разчлененост;

От гледна точка на инженерната математика тези параметри могат да бъдат измерени или определени по изчислителен път, а именно: коефициент на абсорбция на вода, водопропускливост, порьозност, коефициент на филтрация.

В доклада е представена технологията за ликвидиране на кухините зад бетоновия крепеж в галерия Кинга на солна мина Величка с помощта на шинесто-циментови разтвори и сондажно-инжекционни методи. Инжекционните процедури извършени по гореспоменатия начин прекратяват изтичането на вода през бетонния крепеж, като се създават условия за равномерно разпределение на хидростатичното налягане, действащо в бетонния крепеж на изработката и се създават условия за съвместна работа на бетоновия крепеж и скалния масив.

ТЕХНОЛОГИЯ НА РАБОТА ПРИ ЗАПЕЧАТВАНЕ НА СТРУКТУРАТА НА БЕТОНОВИЯ КРЕПЕЖ НА ИЗРАБОТКАТА

Запечатването на бетоновия крепеж на изработката се осъществява по сондажно-инжекционен метод.

Това се осъществява посредством прокарване на сондажи в залата предвидена за запечатване и в съседство до нея, след което се извършва инжектиране на циментиращ разтвор под налягане.

Разнообразните геоложки и минно-технически условия изискват създаването на различни мрежи от инжекционни сондажи с определени дължини и в определен ред.

Сондажните работи са осъществени на следния принцип:

1. Ред на извършване на инжекционните работи
2. Разположение на сондажите
3. Реологични свойства на инжекционни разтвор
4. Налягане при инжектиране

По принцип, шахта Кинга и околния скален масив са запечатани от най-ниското ниво към устието на шахтата. Работата по запечатването е разделена на няколко етапа, които се отнасят до частите на шахтата, преминаващи през различните нива на солна мина Величка. И така, с оглед на горепосочените принципи, крепежът между долнището и ниво

VII е запечатан първи по ред. Това е последвано от крепеж на шахтата под площадка VIII.

На дълбочина от 197,97 до 296,53 м, крепежът на шахтата е изграден от бетонови блокчета с дебелина 0,5м. Най-напред са прокарани вертикални сондажи, извозни галерии разположени на изток и на запад от шахта Кинга от нивоVIII. От всяка страна са просондирани 3 сондажа на разстояние около 1,5м от крепежа. Два сондажа, прокарани от стълбищното отделение са разположени на разстояние 0,5м от стените , а третият е по оста на извозната галерия. Те са показани на фиг.1 катоP81, където 8 показва, че сондажите са просондирани от ниво VIII и I показва ,че това са вертикални сондажи от 1 до 6. Дължината на всеки един от сондажите е 11,7м.

Вторият етап на запечатване на крепежа на шахтата под ниво VIII се състои в изграждане на пет запечатващи пръстена на разстояние 2,25м един от друг. Прокарани са Таблица 1 инжекционни сондажи в дължина 2м и 60мм диаметър от вътрешната страна на шахтата.

В крепеж на шахтата между площадка VII и площадка VIII

Първо са направени два хоризонтални кръга, а след това са просондирани вертикални инжекционни сондажи от площадка VII

- Три запечатващи пръстена, състоящи се от пет хоризонтални сондажа, всеки с дължина 2,0м
- Три запечатващи пръстена, съставени от пет хоризонтални сондажа, всеки с дължина 0,7м
- Три вертикални сондажа от източната страна на извозната галерия, на 1,5м от вътрешната страна на крепежа и с дължина 11,0м

Последващите работи са планирани така, че да запечатат шахтата и съседният скален масив в съответствие с прилаганите технологии.

Таблица 2 Technical parameters of saline cement-bentonite slurry determined in 20 (±2) °C (293 K).

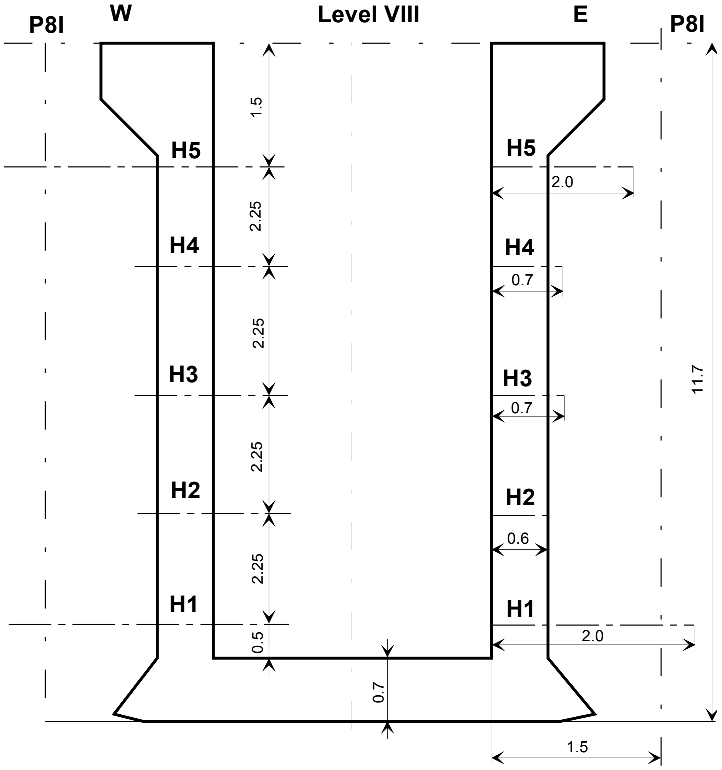

Figure 1. Location of injection wells below the level VIII.

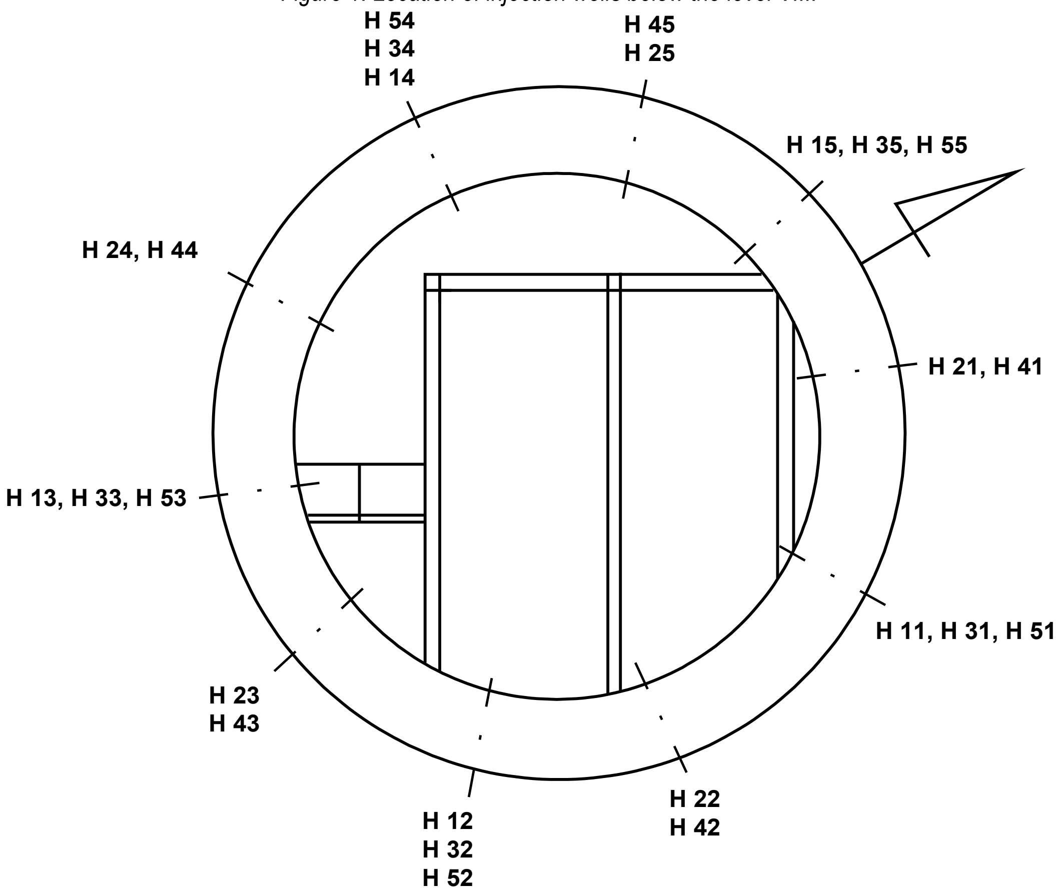

Figure 2. Location of injection wells below the level VIII in the Kinga shaft.

ИЗБОР НА ЦИМЕНТИРАЩИ РАЗТВОРИ ЗА ОБЕЗОПАСЯВАНЕ НА ШАХТА КИНГА

Ефективното запечатване и укрепване на крепежната шахта Кинга и съседния скален масив, е необходимо да се разработят специални рецепти за циментиращи разтвори, подходящи за разнообразните геоложки условия в скалния масив и за материала, от който е изработен крепежа. При разработване на рецептите за циментиращите разтвори беше отделено специално внимание на добрата съвместна работа със скалния масив и повишена устойчивост към агресивни корозионни агенти.

- Металургичен цимент СЕМ III/A-32,5;
- Алкален активатор-Na_2CO_3
- Минерални добавки под формата на бентонитна глина
- Наситен разсол от мина Величка

Бентонитната глина е добавена към циментиращия разтвор за да:

- намали филтрацията на циментиращия разтвор;
- намали седиментирането и увеличи стабилността и то специално на циментиращите разтвори с повишено съдържание на вода;
- да уеднакви механичните параметри на втвърдения циментиращ разтвор с параметрите на циментирания и укрепен скален масив и крепежа на шахтата;
- да увеличи пластичността на втвърдения циментиращ разтвор;
- да понижи пропускливостта на втвърдения циментиращ разтвор в резултат на действието глинените частици, които блокират парите

Натриевият карбонат се използва за:

- активатор
- пластификатор
- компонент, осигуряващ добра работа със скалния масив, и по-специално масива от глинест тип.

Разсол 1200kg/m^3 от мина Величка се добавя към циментиращия разтвор. Неговият химичен състав е следният:

Разсолът от мина Величка е много агресивен към бетона и зазравяващия циментиращ разтвор.

Типът на инжектирания през сондажите циментиращ разтвор зависи от:

- приетия обхват на проникване на циментиращия разтвор зад крепежа;
- тип и технологическа характеристика на крепежа (порьозност, пропускливост, коефициент на филтрация, напуканост и хидравлична връзка с външната повърхност на бетона);
- технологичните параметри на свежия и втвърдения циментиращ разтвор, (плътност, реологични параметри, време на свързване на циментиращия разтвор, механични параметри на втвърдения разтвор)
- при инжекционните работи, свързани с циментиране на скалната маса зад крепежа на шахтата и самия крепеж са необходими поне три рецепти на солени циментиращи разтвори (таблица 1)
- основен разтвор (SK1)
- разтвор, който ликвидира изходите зад крепежа и страничните стени (SK2)
- циментиращ разтвор (пълнител) (SK3)

Основните технологични параметри на циментиращите разтвори, използвани при укрепване на облицовката на галерия Кинга и вместващия скален масив са представени на таблица 2.

ИЗВОДИ

1.Многогодишната експлоатация на крепежа на галериите и влиянието на скалния масив и водите, в него често води до необходимост от укрепване и запечатване на крепежа.
2.Реологичните свойства на разтвора, разположението на инжекционните сондажи, последователността на сондажните работи и крайното налягане, при което се инжектира утайката са съществени параметри на инжекционния метод за подобряване на тектонското състояние на крепежа.
3.Използваните циментационни разтвори са изготвени на базата на наситен разтвор са доказали своята ефективност в условията на солна мина Величка.

SEALING OF CAVITIES BEHIND THE CONCRETE LINING OF THE KINGA SHAFT IN THE WIELICZKA SALT MINE

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ABSTRACT

Long-term mining activities in the Wieliczka Salt Mine resulted in a fresh water flux of varying intensity to the salt formation behind leached caverns in the salt rocks.
Safety hazards of the Wieliczka Salt Mine have been discussed with a focus on the existing quality of the Kinga shaft concrete lining, as well as the disturbed geological, hydrogeological and mining conditions in the shaft vicinity.
The injection method, applied for the strength improvement of the concrete lining and for sealing of the surrounding salt formation, has been described.

INTRODUCTION

Technical-engineering conditions in concrete constructions, especially in shaft lining, belong to factors limiting the correct and economic performance of sealing with borehole injection methods.

The aim of injection works in shaft lining may be the following:

- **direct improvement of physico-chemical properties of the lining;**
- **lowering water permeability of the lining.**

The above objectives can be obtained only when

- **technical design of injection procedure;**
- **design of injection technology;**
- **selection of recipes and technological parameters of sealing slurries;**
- **injection works**

are performed correctly.

All kinds of physical discontinuities appearing in the shaft lining in the immediate neighbourhood play a crucial role in water permeability.
Physical discontinuities may form complex networks of fractures, which can be characterized by means of a number of properties, the so-called fracturing parameters, e.g.

- **spatial orientation of fractures;**
- **linear dimension of fractures;**
- **degree of cracking;**
- **degree of divisibility.**

From mathematical-engineering the point of view these parameters can be determined by means of measuring or calculation methods, e.g. unit water absorptivity index, permeability, porosity, filtration coefficients.

The aim of the paper is to present the technology of liquidation of voids behind the lining of the Kinga shaft in the Wieliczka Salt Mine with the use of clayey-cement slurries and borehole injection methods. Injection procedures carried out in the above mentioned object liquidated water leakages through the lining, creating conditions for uniform distribution of hydrostatic pressures acting on the shaft lining, and generated conditions in which the lining could co-operate with the rock mass.

TECHNOLOGIES OF WORKS FOR SEALING THE SHAFT STRUCTURE

Sealing of the shaft lining was realized by the borehole injection method.

This solution lied in making boreholes in the planned sealing area of the shaft and neighbouring rock mass followed by injection of sealing slurry under pressure.

Due to the varying technical and mining-geological conditions, grids of injection wells were made, at arbitrary length and order.

The wells were made with the use of varying techniques [1]:

1. **order of injection works;**
2. **location of drilling wells;**
3. **rheological properties of sealing slurry;**
4. **injection pressure.**

As a principle, the Kinga shaft and rock mass were sealed from the lowermost level towards the shaft site. The sealing operation was divided into a few stages concentrating on different parts of the shaft passing through the specific levels of the Wieliczka Salt Mine. And so, in line with the above principles, the lining between the floor and the level VII sealing was sealed in the first order. This was followed by making:

5. **the shaft lining below the level VIII.**

At a depth of 197.97 to 296.53 m the shaft lining was made of bentinite bricks 0.5 m thick. First, vertical boreholes were drilled from gangways sited at the east and west part of the Kinga shaft, from the level VIII. At each side, 3 boreholes were drilled at about 1.5 m distance from the lining. Two boreholes in the gangway were located 0.5 m from the side walls, and the third one was in the gangway axis. They were shown in the Figure 1 as P8I, where 8 denoted that the holes were drilled from the level VIII and I signified that it was a vertical borehole from 1 to 6. The length of each of the boreholes was

11.7 m.

The second stage of sealing the shaft lining below the level VIII lied in making five sealing rings at 2.25 m distance from one another. Injection wells 2 m long and 60 mm diameter were made from inside of the shaft:

- **shaft lining between levels VII and VIII.**

First, two horizontal sealing rings were made, followed by vertical injection wells drilled from the level VII

- **three sealing rings consisting of five horizontal boreholes, each 2.0 m long;**
- **three sealing rings consisting of five horizontal boreholes, each 0.7 m long;**
- **three vertical boreholes on the east side of the gangway, 1.5 m from the inside of the lining and 11.0 m long.**

Further works were so scheduled as to seal the shaft and the neighbouring rock mass in compliance with applied technologies.

SELECTION OF SEALING SLURRIES FOR SECURING THE KINGA SHAFT

To efficiently seal and reinforce the Kinga shaft lining and the neighbouring rock mass, it was necessary to elaborate recipes for slurries adjusted to the variable geological conditions in the rock mass and also material making up the shaft lining. When working out recipes of sealing slurries, attention was paid to the good co-operation with the rock mass and increased durability in corrosion-aggressive conditions.

To elaborate sealing slurries for securing the Kinga shaft, the following solutions were applied:

- **metallurgical cement CEM III/A – 32.5;**
- **alkaline activator – Na_2CO_3;**
- **mineral additives in the form of drilling bentonite silt;**
- **fully saturated Wieliczka brine.**

Bentonite silt was added to the sealing slurry in order to:

- **lower filtration of sealing slurry;**
- **lower sedimentation and increase stability, especially sealing slurries with increased water-mixing properties;**
- **adjust mechanical parameters of hardened sealing slurry to the parameters of sealed and reinforced rock mass and shaft lining;**
- **increase plasticity of hardened sealing slurry;**
- **lower permeability of hardened sealing slurry as a result of silt particles blocking the pores.**

Sodium carbonate was used as an:

- **activator of bonding time;**
- **plastifier;**
- **component securing good co-operation with the rock mass, especially of the clayey type.**

Brine 1200 kg/m^3 from Wieliczka Salt Mine was used for making sealing slurries. Its chemical composition was as follows:

NaCl	305 g/l
Ca^{2+}	1.05 g/l
Mg^{2+}	0.22 g/l
NH_3	0.02 g/l
HCO_3^-	0.21 g/l
pH	7.5

Wieliczka brine is very aggressive to concrete and hardened cement slurries.

The type of injected sealing slurry through injection wells depended on:

- **assumed range of penetration of the slurry beyond the lining;**
- **admissible slurry injection pressure;**
- **type and technical condition of shaft lining (porosity, permeability, filtration coefficient, fractures and hydraulic connections with external surfaces of the lining);**
- **technological parameters of fresh and hardened sealing slurry (density, rheological parameters, bonding time of slurry, mechanical parameters of hardened slurry).**
- Injection works connected with sealing of the rock mass beyond the shaft lining and the lining itself will require minimum three recipes for saline sealing slurries (Table 1)
- **basic slurry (SK1);**
- **slurry liquidating escapes from behind the lining and side walls (SK2);**
- **sealing-filling slurry (SK3).**

Basic technological parameters of sealing slurries used for sealing and reinforcing the Kinga shaft lining and the surrounding rock mass are presented in Table 2.

Table 1 Mass of components used for making 1 m^3 of saline sealing slurry.

Table 2 Technical parameters of saline cement-bentonite slurry determined in 20 (±2) °C (293 K).

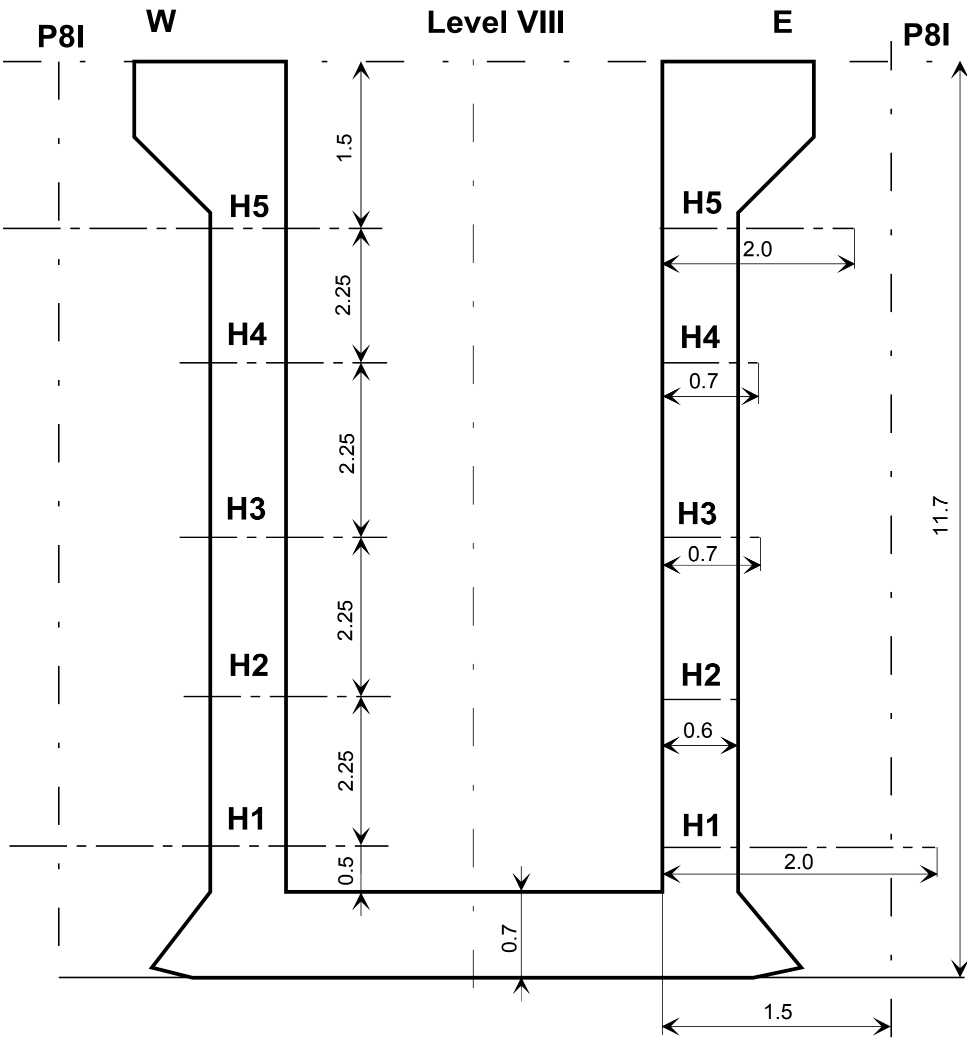

Figure 1. Location of injection wells below the level VIII.

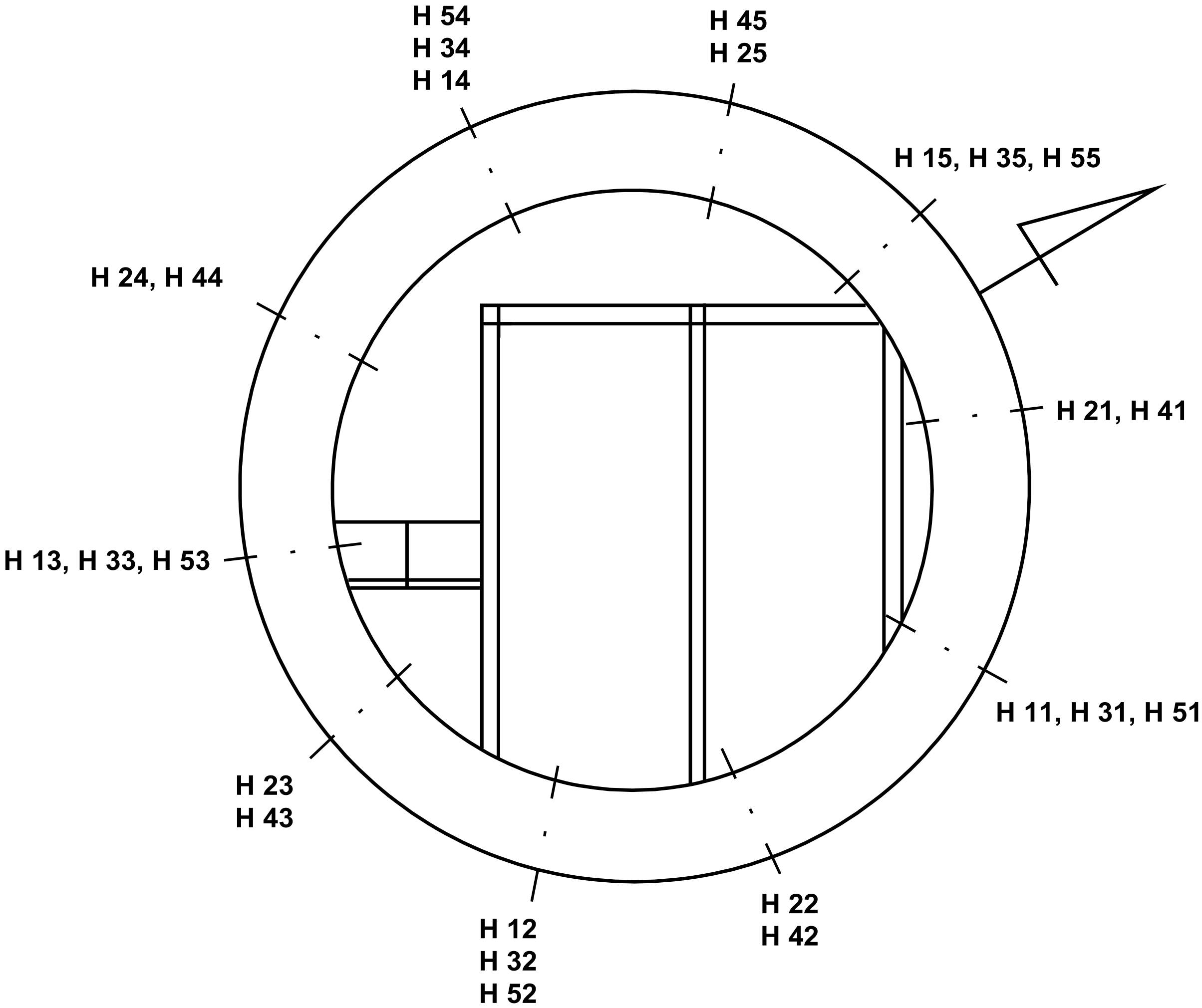

Figure 2. Location of injection wells below the level VIII in the Kinga shaft.

CONCLUSIONS

1. **Many years exploitation of shaft linings under the influence of the rock mass and the surrounding waters often necessitates reinforcement and sealing of the lining.**
2. **Rheological properties of slurry, location of injection wells, order of injection works and final pressure at which slurry is injected are important parameters in the injection method used for improving the tectonic state of the shaft lining.**
3. **The applied slurries were made on the basis of fully saturated brine proved to be very useful in the conditions of the Wieliczka Salt Mine.**

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Recommended for publication by Department

, Faculty of Mining Technology

SPECIFICITY OF GEOTHERMAL DRILLINGBASED ON OIL AND GAS EXPLORATION COMPANY JASŁO ACTIVITIES

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ABSTRACT

Geothermal Energy is very often an area of interest to local communities and beyond (Poland, EU). The reason for it is the cleanness of such energy and its good accessibility. Therefore, it is possible to receive the energy source in certain area and make the area partly independent from conventional energy providers. The limiting factor is the high cost of making the underground heat available. Drilling of geothermal wells is most often the most expensive part of geothermal projects.

The paper presents technical and technological aspects of drilling geothermal wells, based on Polish and Slovak experience.
The construction of chosen vertical and directional geothermal wells in various geological and reservoir conditions is presented in the paper. Applied bits, drilling mud and drilling technique with a downhole motor, are discussed. Special attention was paid to the difference between geothermal drilling and oil and gas drilling. The drilling progress results, which are an important factor influencing the geothermal installation cost reduction, close the paper.

INTRODUCTION

Geothermal energy belongs to the renewables, a subject of interest to World's political and economic elites. This is caused by the perspectives of finding new energy sources as well, as ecological and social advantages of geothermal energy. The efficiency of the whole undertaking depends on such factors as geological, hydrogeological and reservoir conditions, development techniques for exploitation and use of thermal waters as well as financing. The management of geothermal energy in the first phase of realization is related with high investment costs, which in the long run are compensated by low costs of exploitation. Among all investment costs, drilling costs are the highest.

DRILLING OF GEOTHERMAL WELLS IN POLAND

The first experimental geothermal well in Poland, Bańska IG-1, was drilled in the Podhale Basin in 1981 in the area where thermal waters reside in fractured carbonaceous Eocene and Miocene rocks at a depth of 2000 to 3200 m. Its productivity is 60 m^3/h at wellhead pressure 2.6 MPa and temperature on outlet ca.72 °C. The reservoir temperature ranges between 84 and 90 °C. Estimates are made that $4513.5 \cdot 10^{15}$ J thermal energy is gathered in a geothermal reservoir covering an area of 450 km^2. What is advantageous about thermal waters in the Podhale Basin is their very low mineralization, below 3 g/dm^3, and arthesian character.

In 1992 a geothermal doublet made of wells Bańska IG-1 and Biały Dunajec PAN-1, started to operate. It is run by the Experimental Geothermal Station, Polish Academy of Sciences. Geothermal heat is delivered to about 200 customers. Another geothermal doublet (well Bańska PGP-1 and well Biały Dunajec PGP-2) was made by the Oil and Gas Exploration Company Jasło. Apart from drilling works, the whole heat transport infrastructure

between Nowy Targ and Zakopane has been provided as well. After setting up the third planned doublet (well PGP-4 and well PGP-5), the heat sale in the Podhale Geothermal should, according to P. Długosz (2001), amount to 1.2 mln GJ at the end of the year 2005. An alternative is taken into consideration to supplement the missing geothermal power by absorption heat pumps and lowering of temperature of water injected to the wells.

To increase the output and absorption properties of geothermal wells, in some cases stimulation procedures are recommended. This, however, mainly depends on the geological-reservoir conditions. According to E. Garbarz and S. Gazda (2001), the acidification procedures carried out in wells PGP-1 and PGP-2 caused penetration of the fluid in the reservoir followed by chemical reactions, which in turn, resulted in the increased productivity from about 88 m^3/h to about 250 m^3/h.

Favourable geothermal conditions can be found on a predominant part of Poland. The activity of Geotermal Station in Pyrzyce is the best evidence of it. In the years 1992 to 1993 NAFTGAZ Wołomin, now part of Oil and Gas Exploration Company Jasło, performed four geothermal wells. These are production wells GT-1 and GT-3, as well as injection wells GT-2 and GT-4. They are sited on the Liassic sandstones in the Lower Jurassic at a depth of 1500 to 1680 m where the thermal water at 62 to 64 °C is mineralized to about 110 g/dm^3. The water table in the wells stabilized at a depth of about 34 m from the surface. Therefore, in order to install deep pumps 9 ½", the casing 9 5/8" in the production wells GT-1 and GT-3 had to overlap with the casing 13 3/8". The pumps were tripped on pipes 8 5/8 to a depth of about 150 m. The injection wells GT-2 and GT-4 were cased with 9 5/8" to the top. The casing shoes in all four geothermal wells were located right under the top of the production layer. Further drilling was carried out with bits 216 mm in diameter and diamond tools 8 ½" of diameter and clay-free polymer mud of a density reaching about 1060 kg/m^3. To improve the conditions of geothermal water flux to exploitation wells and its re-injection to the reservoir, all wells were broadened to a diameter of 420 to 430 mm with a hydraulic reamer. Then, the casing 13 3/8" and 9 5/8" was cleaned with scrubs and the near well zone by a few operations of reservoir water exchange. Johnson filters 6 5/8" made of stainless steel 304L, fractures 0.5 mm and active surface 11 to 14 %, were tripped to these wells. Individual filter sections were so selected as to locate their active parts in sandstone; to properly dispose filters in the well, they were additionally equipped with dielectric centralizers 6 5/8" $\times$ 15". Filter sets were equipped with a hanger and device for gravel pack disposal around the filter. They were tripped on mud pipes 3 ½" to the planned depth to be later suspended on a hanger (Fig. 1).

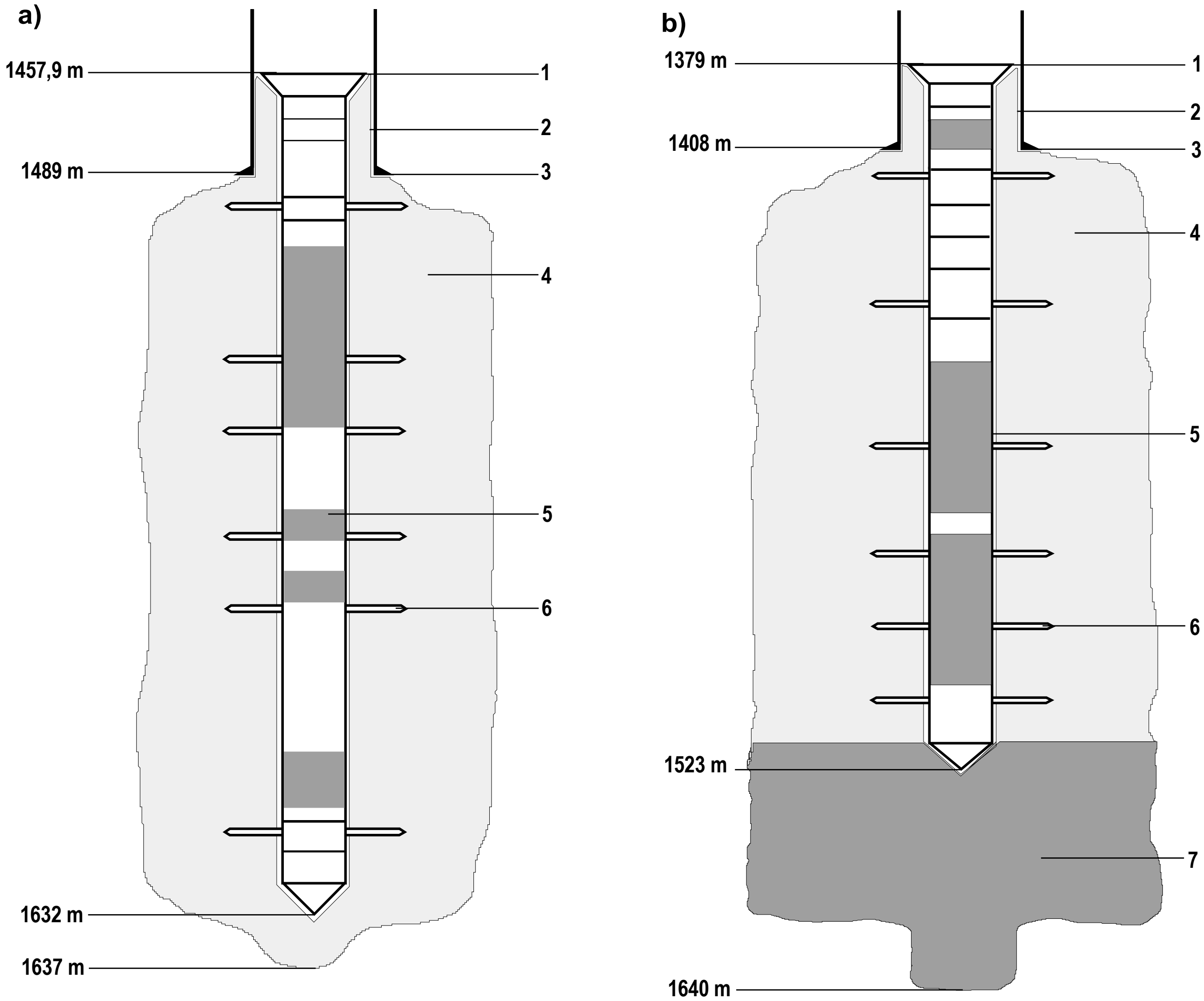

Figure 1. Scheme of: a) thermal water intake by well Pyrzyce GT-1, b) gravel pack filter in the injection well Pyrzyce GT-2 [4]: 1 - hanger + dielectric connection, 2 - protecting sieve, 3 - casing (9 5/8"), 4 - gravel pack (quartz sand 0.8 to 1.4 mm from Biała Góra, near Tomaszów Mazowiecki, Poland), 5 - Johnson filter 6 5/8" 130 Bar slot 0.5 mm, 6 - dielectric centralizers 6 5/8" x 15", 7 - gravel pack 1 to 3 mm.

The gravel pack was selected as to match the grain size of the drilled sandstones and quartz gravel 0.8 to 1.44 mm and 1 to 3 mm, respectively. The pack was very clean and of specific grain size.

The quality of the performed geothermal wells in the initial stage of production can be evaluated on the basis of the results of cleaning pumping operations with the use of air lift. The pumping was realized for three increasing rates from 60, through 90 to 170 m^3/h. The absorption wells received injected water at a maximum rate of 170 m^3/h at wellhead pressure 0.6 to 0.8 MPa. In the years 1990 to 1991 and 1996 to 1997 NAFTGAZ Wołomin performed analogous works in Skierniewice, where at a depth of 2875 to 2945 m and 2997 to 2886 m thermal waters at 68 °C were found in the Lower Jurassic sandstones. More detailed information presented J. Kilar et al, 2001.

DRILLING OF GEOTHERMAL WELLS IN SLOVAKIA

In 1997, The Oil and Gas Exploration Company Jasło started drilling operations for Geoterm Kosice, described by A. Gonet et al., 1999. Their objective was to make thermal waters accessible in the area of Durkov, about 15 km from Kosice. First a vertical well GTD-1 was drilled, then two directional wells GTD-2K and GTD-3K were completed with a rig IRI 1200.

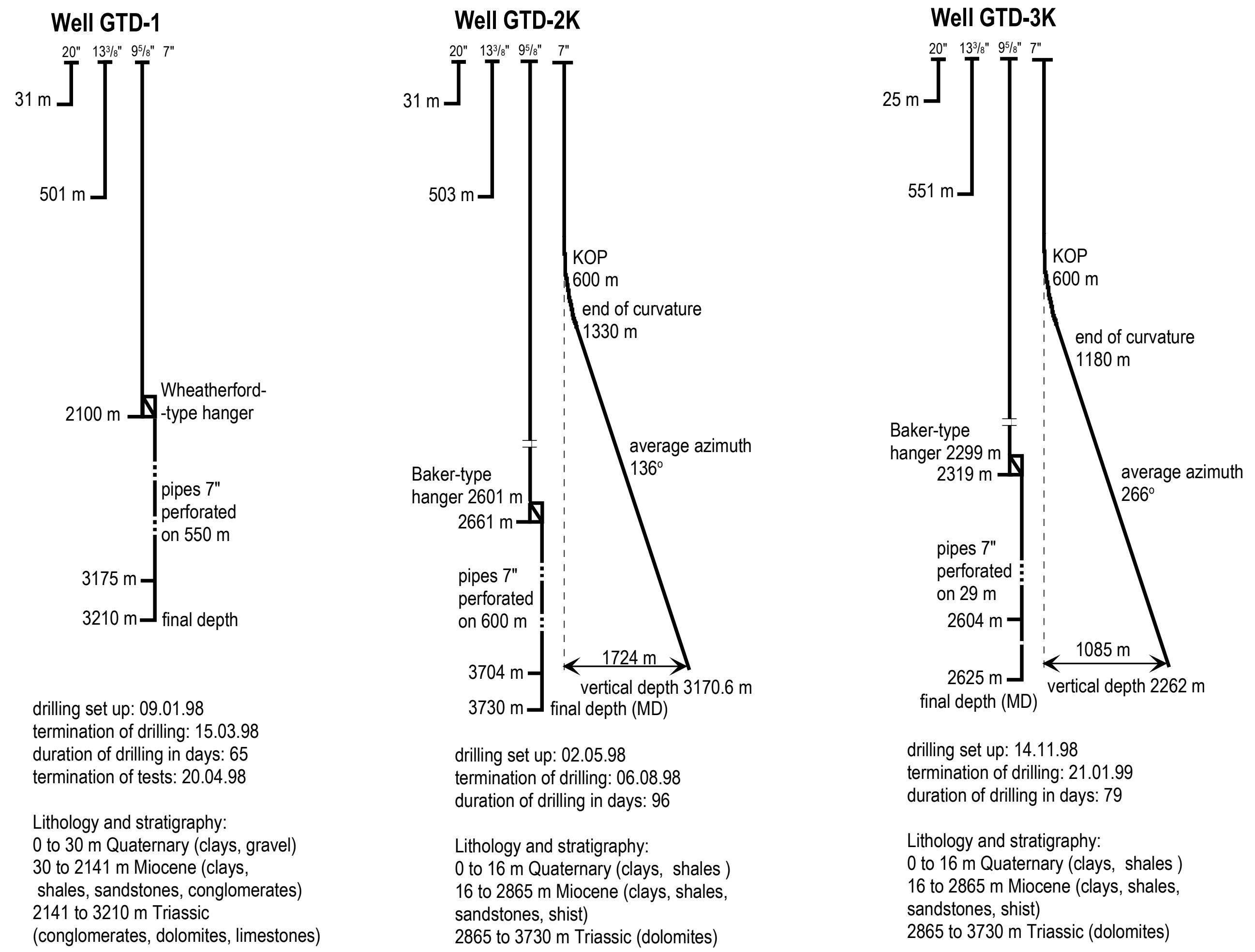

Figure 2. Profiles of geothermal well axes in the region of Durkov [2].

As a result the area of the aquifer intaking has to be increased and surface installment related with thermal waters management shortened.

Among the problems related with drilling of these wells, most prominent is the problem of drilling mud selection, casing, sealing of casing and drilling through the reservoir interval.

Practical experience has confirmed that the use of potassium-polymer mud was the right choice. A good technical state of the well and favourable technical-economic parameters of drilling were obtained. The latter was strongly influenced by the rig with a very efficient mud cleaning system, applied bits and parameters of drilling technology. Additionally, drilling wells were checked for proper lubrication and rheological parameters. When casing, attention was paid to the influence of temperature on elongation of steel pipes and on technology and efficiency of cementing. This manifested in disposal of a casing hanger compensating pipes elongation, and cementation collar to create a pumping chamber at a specific depth in the well. When getting to the aquifer zone, clay-free mud based on biodegradable polymers was used. To avoid colmatation of the aquifer, in the case of lost circulations no blockers or filling materials were applied. In the case of extreme lost circulations chemically treated water was used. The continuity of drilling works required constant water supplies to the rig and correct prevention of the outlet, to avoid eruptions of mineralized hot water to the surface.

Another unfavourable phenomenon in the drilling area was the influence of CO_2 contained in thermal waters, resulting in increasing corrosion and premature fatigue cracking of the string. To limit this unfavourable process, attempts were made to maintain mud pH in the range from 8.5 to 11. Another solution lies in using inhibitors of adsorption-type corrosion or internal lining of the string.

CONCLUSIONS

6. **Geothermal energy is more frequently used because of ecological, social reasons. Another important factor is the considerable reserves of thermal energy.**

7. **When drilling geothermal wells it is recommended to use mud with very low solid content. Not to deteriorate the permeability of the reservoir zone, no blockers or filling materials should be used when drilling through the aquifer. Additionally, it is advisable to use a very good cleaning system for removing cuttings from the drilling mud.**

8. **Selecting the string, it is necessary to have the recipes for drilling mud, cement slurry and piping to account for the influence of temperature and mineralization of thermal waters.**

9. **To improve production and absorption parameters of geothermal wells, the following procedures are recommended:**

- reaming, if sandstone makes up the reservoir layer;
- acidification, if limestones and dolomites make up the reservoir layer.

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