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SPECIFICITY OF GEOTHERMAL DRILLING BASED 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 ^oC. The reservoir temperature ranges between 84 and 90 ^oC. 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 ^oC 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" × 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).

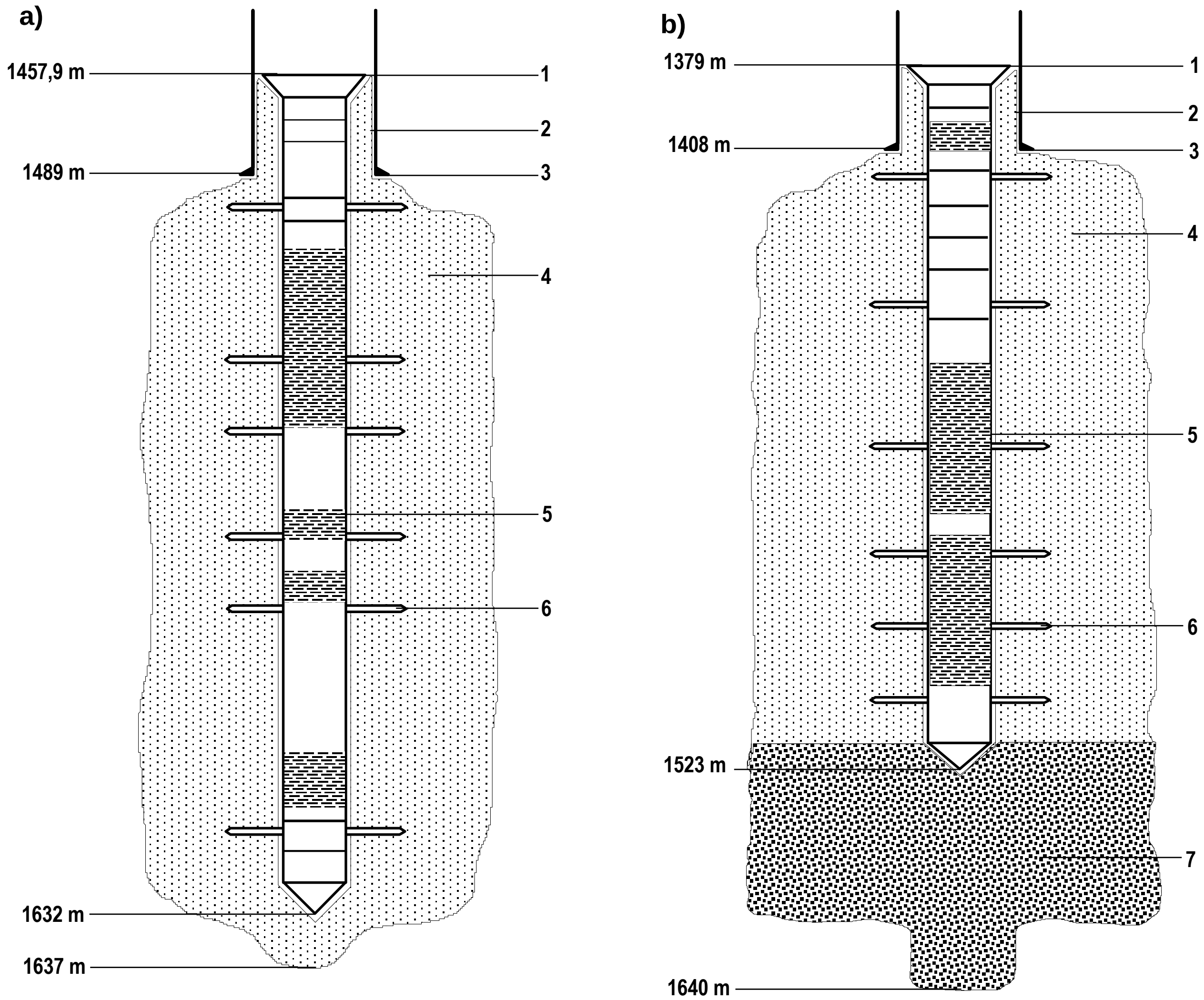

Figure 1. Scheme of: a) thermal water intake by well Pyrzyce GT-1, b) gravel pack filter in the injection well Pyrzyce GT-2 [4]: 1 - hanger + dielectric connection, 2 - protecting sieve, 3 - casing (9 5/8"), 4 - gravel pack (quartz sand 0.8 to 1.4 mm from Biała Góra, near Tomaszów Mazowiecki, Poland), 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 ^{o}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.

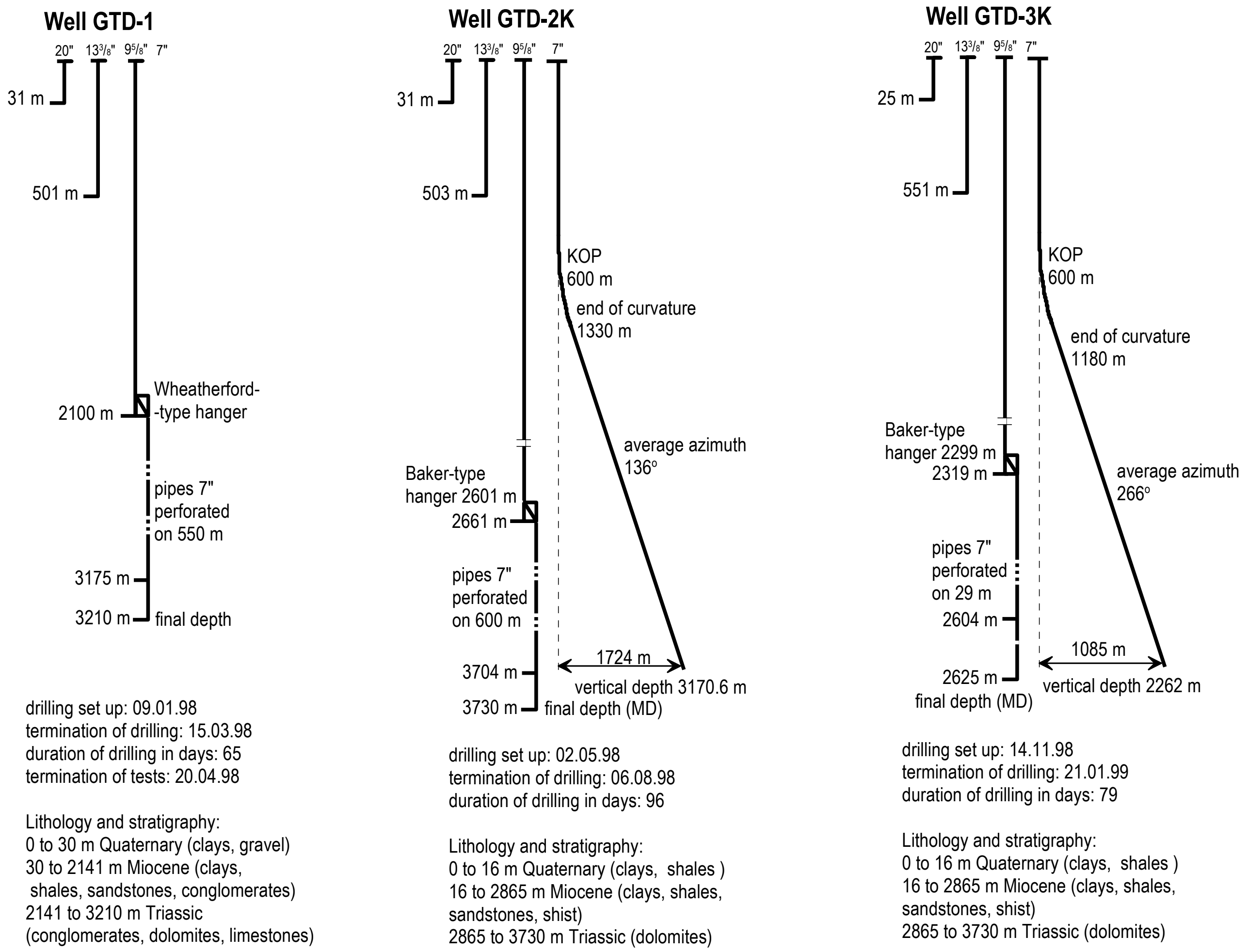

Figure 2. Profiles of geothermal well axes in the region of Durkov [2].

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

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

2. 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.

3. 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.

4. 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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