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HYDROCARBON WELL TESTING AS PART OF GEOTHERMAL EXPLORATION IN HUNGARY

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ABSTRACT

MOL Hungarian Oil & Gas Plc. organized a consortium to develop a geothermal pilot project to explore power plant opportunities offered by geothermal resources in Hungary. The technical concept included utilization of existing abandoned hydrocarbon wells in the southwestern part of Hungary for producing and reinjecting thermal water. The exact flow rate was unknown because the exploratory drilling initially focused on hydrocarbons; therefore, thermal water production and reinjection tests were necessary.

After the wells were completed, two decommissioned hydrocarbon wells were converted to thermal water production or reinjection wells as part of the testing phase. Thermal water was extracted from the wells into a pit near the well. Then the produced thermal water was reinjected back to its own aquifer through the same well. The collected data were then analyzed. Highlighting this new approach in Hungarian geothermal exploration are the utilization of abandoned hydrocarbon wells, the establishment of an international consortium for thermal water exploration, as well as the unusual depth of the wells, the fairly high temperature, and the focus on power plant establishment. This pilot project started a new segment in the history of Hungarian geothermal exploration. Based on the project results, the consortium members established a joint company for developing further geothermal projects.

1. BACKGROUND

The geothermal potential of Hungary is well above the world average and, except for active volcanic areas, it is one of the most promising territories in Europe. In spite of this fact, there are hardly any geothermal energy facilities in Hungary, and those few are operated on a less environmentally sound basis, i.e., 100% of the extracted water is not injected back into the well. No geothermal power plant facility exists in the country.

MOL Hungarian Oil & Gas Plc. decided to set up a team to develop a geothermal pilot project to explore power plant opportunities offered by geothermal resources in Hungary. This team analyzed potential geographical locations where the volume and heat of extracted water would be adequate for a geothermal power plant.

The pilot project has been set up with investor partners. MOL, Enex ehf. of Iceland and Vulcan Kft. (its owner is Green Rock Energy Ltd. of Australia) established a consortium in which MOL is the operator. The pilot project was implemented, and the results were analyzed. The consortium partners declared that the geothermal strategy is working, and decided to widen their co-operation. They established a joint company, CEGE Central-European Geothermal Energy Production Private Company Ltd. The mission of this geothermal company is to be a market leader in geothermal energy production in Hungary; therefore, this company has to face all technical challenges in the Hungarian geothermal industry.

2. EXPLORATION OF DEEP LAYERS: A NEW SEGMENT IN HUNGARIAN GEOTHERMAL EXPLORATION

Hydrocarbon exploration has been going on in Hungary for seventy years. During this long period more than 8000 deep well were drilled in the small territory of the country. Crude oil and natural gas exploration have been generally successful; however, there are a lots of abandoned hydrocarbon wells in the country.

Figure 1 shows the distribution of hydrocarbon wells in Hungary. As part of the Pannonian Basin, the major part of the country holds great promise for geothermal exploration. The distribution of the hydrocarbon wells covers this major part.

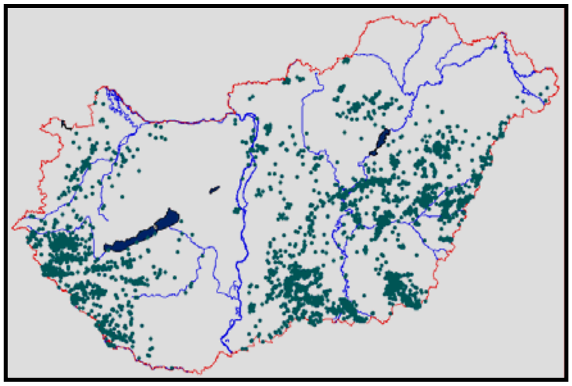

Figure 1: Distribution of hydrocarbon wells in Hungary.

Earlier there was no direct geothermal exploration in Hungary that focused on layers below 2500 meters. All information regarding deep geothermal waters originated from hydrocarbon wells.

The MOL-Enex-GreenRock pilot project started a new segment in the history of Hungarian geothermal exploration. The main characteristics of this new segment is

- deeper wells (2 – 4 km)
- higher temperatures (120 – 170^{o} C)
- reinjection of 100% of the extracted thermal water into its own reservoir.

The pilot project, (started in 2005, finished in 2007) was the first attempt to directly explore geothermal waters below 3000 meters. Therefore, the experiences and lessons of the tests at the abandoned hydrocarbon wells can be useful in the exploration of sedimentary basins.

3. ADVANTAGES AND DISADVANTAGES OF HYDROCARBON WELLS IN GEOTHERMAL EXPLORATION

The decision to test existing wells is a key question in the geothermal exploration concept in Hungary. Moreover, the issue of an existing well is immediately presents two choices: to test one well only or to test a doublet to form a production-reinjection site.

The main advantage is the cost. Earlier, the expectation was a 50-60% cost saving in the drilling phase for every well. The experience is that only 40-50% can actually be achieved. However, the cost of formation treatment is necessary; therefore, the 100% relates to the pure drilling.

The second and surer advantage is the existence of well files. In several parts of the country a complete regional analysis can be prepared from well documentation. The most promising wells can be selected for thermal water testing. In lucky cases doublets can be found that include production and reinjection wells. The existing cores can be analyzed (Figure 2).

There is no difficult licensing process for utilizing existing wells.

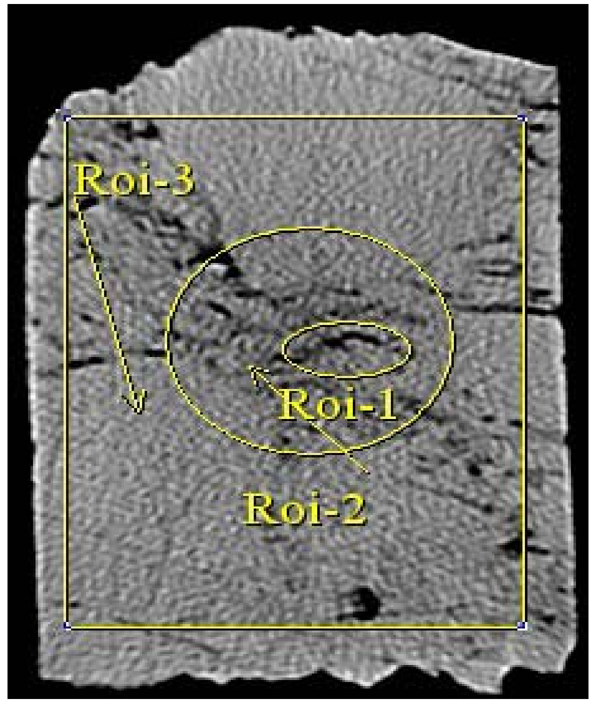

Figure 2: Computer topographic analysis of existing cores.

However, the utilization of existing hydrocarbon wells has also numerous disadvantages.

- When planning for hydrocarbon exploration, experts wish to avoid natural fractures to prevent water inflow. Therefore, only the most unlucky wells can be considered promising for thermal water production.
- The promising abandoned wells can be very old (30-40 years) and their physical condition is doubtful (Figure 3).
- Their documentation is often incomplete or inadequate; there is relatively little information on thermal water productivity.
- The hydrocarbon wells are designed for producing a much lower flow rate than the expectation is in a thermal water project. Therefore, occasionally the water capacity is not sufficient, and another production or reinjection well is needed. The thermal water capacity of an existing hydrocarbon well is generally not enough for production from a single well.
- The cement column is often not appropriate for long term, very hot water production.
- The temperature insulation of the wells is generally not already installed.
- It is difficult to find one promising well, but to find a doublet is even more difficult.
- The prospective wells are often far from heat consumption areas.

- The ownership of the wells is not clear in some cases in Hungary.

Figure 3: Head of an abandoned well in the Pannonian Basin.

4. CHALLENGES OF TESTING ABANDONED HYDROCARBON WELLS

The selection of the wells, design of the test phases, construction of the surface facilities, implementation of the tests with data collection, and data analysis constitute different challenges in the process.

The advantages and disadvantages presented in the previous chapter reflect factors affecting well selection. In spite of a significant cost saving, deep well tests are expensive because of the costs for drilling equipment and formation treatment. The construction of a pit is presented in Figure 4. Due to environmental regulations, thermal water collection and reinjection is obligatory.

Figure 4: Construction of a 2000-cubic-meter pit.

The entire testing process consists of two phases. In the first phase wells are tested separately. The thermal water is extracted and put into the pit, and then reinjected through the same well (Figure 5). It is a “short-term test;” its aim is to determine the viability of the well and existence of sufficient water. Pipeline is constructed between wells only after the successful first testing phase.

Figure 5: Thermal water test production from a layer of 142^{o}C temperature in Hungary

The second testing phase includes parallel thermal water production from the production well, transportation of the water by the pipeline, and reinjection through the second well. During this phase, measurements can be carried out in order to collect information for a dynamic reservoir model. Beside flow rate, temperature and pressure measurements, micro-seismic acquisition and evaluation can be implemented as well.

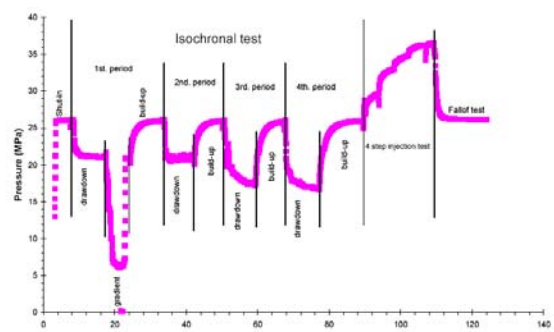

Figure 6: Measured bottom-hole pressure during the testing period (prepared by El-Khatib Mohamed, MOL Technical Team).

The successful design of the testing can be determined only after data selection. We need consistent data rows in order to prepare informative graphs (Figure 6 and 7) and arrange them into order for calculations (Figure 8).

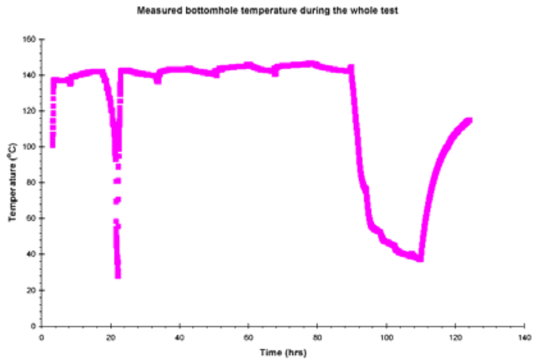

Figure 7: Measured bottom-hole temperature during the testing period (prepared by El-Khatib Mohamed, MOL Technical Team)

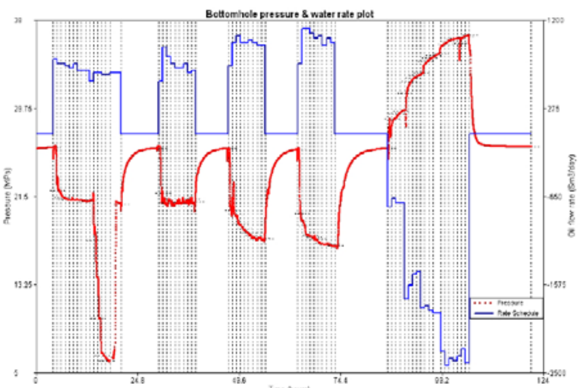

Figure 8: Produced & reinjected water rate and bottom-hole pressure (prepared by El-Khatib Mohamed, MOL Technical Team).

The timing of the testing steps is a key question in the "short-term" phase. The full time is limited because of the capacity of the pit. However, as much information as possible is needed. Therefore, an optimization of the production and reinjection test has to be prepared. Depending on the measurement objectives, it can be worthwhile to implement both one longer step and a few shorter ones with different production rates.

After completing testing, a detailed data collecting and analyzing process started.
The experts of the complex technical team prepared analysis on the following professional areas:

- geology
- geophysics
- drilling
- reservoir engineering
- production engineering
- water chemistry (Figure 9)
- corrosion protection.

All areas give significant information. Figure 9 shows the changing of EC and TDS during a phase. It includes the information about the produced liquid; when does it change from drilling mud into brine from reservoir.

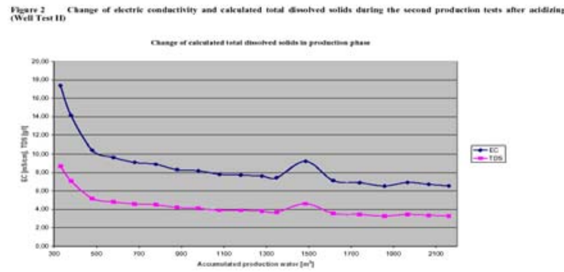

Figure 9: Measured and calculated electric conductivity and total dissolved solids during the second phase of the testing period (prepared by Tibor Csabai, MOL Technical Team).

Based on these analyses a dynamic reservoir model and the detailed economic analysis can be prepared as the next part of the geothermal exploration.

5. SUMMARY

An existing well test requires all intellectual capacities of a geothermal exploration team. In the best case, a significant drilling cost can be saved, but the work phases are the same as in a green field project.

In Hungary, after the pilot testing project the members of the CEGE technical team stated that at least 4-6 geothermal power plants and 50 direct thermal heat service units can be established.
CEGE is developing further geothermal exploration projects. These projects can be a stable basis of the development of the geothermal energy industry in Hungary.

REFERENCES

Bobok, E, (1995) "Geotermikus energiatermelés (Geothermal Energy Production)" *Miskolc University manuscript, Hungary, pp.87-96.*

DiPippo, R, (2005) "Geothermal Power Plants" *Elsevier, pp. 65-72.*

Tóth, A, (2004) "Geotermikus energiatermelő rendszerek hőmérsékletviszonyai (Temperature in Geothermal Production Systems), *PhD Thesis", Miskolc University, Hungary, "Heat Extraction from Abandoned Wells" pp. 64-75.*

Ungemach, P, (2003) "Reinjection of Cooled Geothermal Brines into Sandstone Reservoirs" *Geothermics 32, pp.743-761.*