Individualized Solutions for Turn Key Geothermal Projects – Case Study Geothermal Doublette Lansingerland, NL

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ABSTRACT

Despite favourable political and geological conditions geothermal projects for heat and/or electricity production face significant challenges in regards of structured project financing and execution. An experienced general contractor with the ability to provide project specific construction guarantees and a risk sharing approach can be the key element for the successful execution of geothermal projects. In order to provide turn key solutions a detailed technical and associated risk assessment needs to be performed. A long the way process optimisation and technical updates can be implemented which will lead to faster project realisation. This approach can be applied to the whole value chain of geothermal projects containing on a modular basis the project development and management, road, infrastructure and drilling location construction, conductor installation, well drilling including completion, heat and/or power plant construction as well as district heating network installation. The first successful implementation of this approach was done for the subsurface part of the geothermal doublet Lansingerland, NL.

The production well was designed as an exploration well to encounter all three potential reservoirs (Berkel, Delft and Alblasserdam) and was drilled with a maximum inclination of 54° to a final depth of 2709 m (2114 m TVD). The injection well was drilled with a maximum inclination of 61° to a depth of 2860 m (1859 m TVD). Both wells were successfully drilled with positive displacement mud motors instead of using cost intensive rotable steering systems despite the high inclination of the wells. The well test showed flow rates of up to 400 m³/h, associated temperatures of 60°C and a water/gas –ratio of approximately 1:1. Technical optimisation of operational procedures and specific drilling services as well as project insurance solutions have been accomplished.

1. INTRODUCTION

Warmtebedrijf Berschenhoek B.V. intended to drill a geothermal doublet with purpose to heat greenhouses situated in the Lansingerland region. An appropriate concession is owned by the firm and local construction companies have been contracted to built the drill site and according infrastructure.

Geological studies were done by Panterra Geoconsultants B.V. to investigate the geothermal potential for the concession. The Berkel/Rijswijk Sandstone and Delft Sandstone have been selected as the primary target formations which have the highest geothermal potential. These formations are well known as a geothermal reservoir in the south-western part of the Netherlands. Based on the geological studies the most optimum subsurface locations for producer and injector have been selected and been used for the final well design.

2. RISK ASSESSMENT

In the region several wells have been drilled, either for production of oil in the past but more recently for geothermal purposes. Some of the closest geothermal offset wells are VDB-GT-01 and VDB-GT-02. All available public and additional offset well data has been analysed to assess drilling and completion risks.

Some of these risks are:

- Over the complete Tertiary swelling clays may occur, causing drill pipe to get stuck.
- In the Ommelanden and Texel chalk (total) mud losses may occur. One of the reasons of these mud losses are incised valleys in the Chalk (with permeable channel fill) or open faults.
- The Holland and Vlieland Clays can swell.
- The planned well trajectory cuts through a major fault. Mud losses should therefore be anticipated
- There are several faults in the study area. Minor faults could be present in the subsurface.
- There is a possibility that sub-seismic (i.e. not visible on seismic) faults are present in the area.

The following figure 1 shows an overview of potential drilling risk and associated stratigraphy.

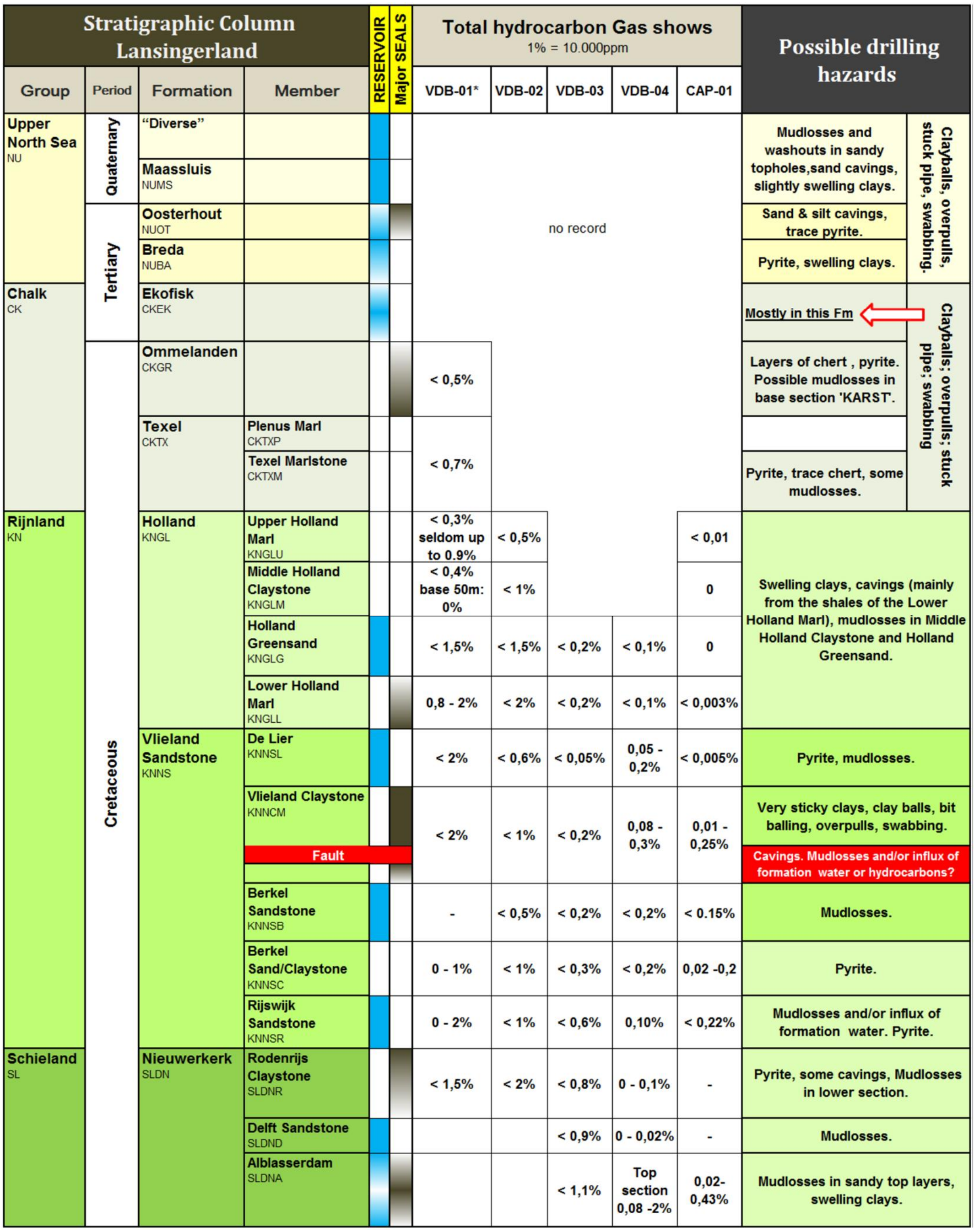

Figure 1: Stratigraphy related drilling risks and hydrocarbon gas show potential for the geothermal wells in the Lansingerland concession.

Based on the identified risk appropriate contingency planning and mitigation measures have been implemented in the execution planning. The following table 1 shows a few of these measures regarding the drilling process.

Table 1: Drilling risks and mitigation measures.

Formation	Drilling hazards	Mitigation measures
Upper North Sea Group	Unstable shallow sands Mudlosses in sandy topholes; Swelling clays; Washouts;	Install deep conductor Use low mud weights Start with low drilling parameters until firm formation has been reached. Inhibitive mud system, minimize open hole time Avoid reaming, limit flowrates.
Chalk Group	Cherts in Ommelanden fm.	Bit selection (have insert bit available at the drill site)
Holland	Mud losses in Holland Greensand	Use low mud weights Lost Circulation Material
Vlieland Sandstone	Swelling clays Cavings Sticky clays / bit balling Fault present in Vlieland Claystone (could cause losses) Mud losses	Inhibitive mud system, minimize open hole time, low fluid loss Maintain low fluid loss, optimize mud weight Inhibitive mud system, use bit with large junk slot area. Optimize mud weight Low mud weight, use LCM
Nieuwerkerk	Pyrite in Rodenrijs Claystone Mud losses in Delft sand	Use bit with back-up cutters Low mud weight

3. SUBSURFACE WORKS

Züblin Spezialtiefbau GmbH in Joint Venture with Huisman Equipment BV executed all subsurface works for the completion of the geothermal doublet in the Lansingerland concession. The production and injection well have been drilled with the rig LOC 400 (360 to hook load capacity) to 2709 m and 2860 m in order to produce thermal water from the Berkel/Rijswijk Sandstone and Delft Sandstone which have been selected as the primary target formations. The drilling works (conductor installation and deep drilling) including all drilling services (drilling fluid and solid control, directional drilling, casing running, cementing, mud logging, wireline logging) as well as the required energy and material supply (casings, float equipment, liner hanger, mud chemicals, wellheads) and the waste management have been part of the contract. In addition, major parts of both well tests including ESP string installation, surface pipework, data measurement and monitoring have been performed by the Joint Venture with a turnkey solution with lump sum contract.

Successful execution was based on the previously performed risk assessment and consequential cost structure as well as on technical optimization measures. The main technical adjustment in the execution phase was the utilization of positive displacement mud motors instead of a rotary steerable systems. This resulted in a severe decrease of exposed downhole risk and associated Lost in Hole insurance premiums.

All sections have been drilled with one bottom hole assembly mostly in one run to desired section depth.

2.1 Drilling and Testing LSL-GT-01

Drilling the 16” section of LSL-GT-01 (Fig. 2) was perfomed as planned included reaming some tight spots.

Drilling to TD (2034 m) of the 12 ¼” section was done after 6 days, later it was decided to set the 9 5/8” shoe higher at 1987 m. To preserve the Berkel formation a weighted high visc pill was pumped and while POOH tight spots had to be reamed. A wash down trip followed by backreaming was also necessary which resulted in total of 4 extra days for this section. Completion with the 9 5/8” liner had to be carried out with extra precaution measures and was successfully washed down to planned shoe depth.

Drilling of the 8 ½ section was initially planned down to 2590 m. It was decided to drill deeper to 2709 m (TD). Actual drilling operation to reach TD lasted 4 days. For preparation of the wireline open hole logging an extra wiper/check trip was conducted. Open hole logging was followed by the cased hole logging campaign. The completion of this section with blanks and screens was then executed to a shoe depth of 2550 m. The lower part of this section to well TD remained open hole.

The following well test was conducted directly after completion within 7 days including a successful fishing operation for the slickline and p/t gauges.

The well testing showed maximum measured flow rate of 399 m³/h and a maximum temperature of 60°C.

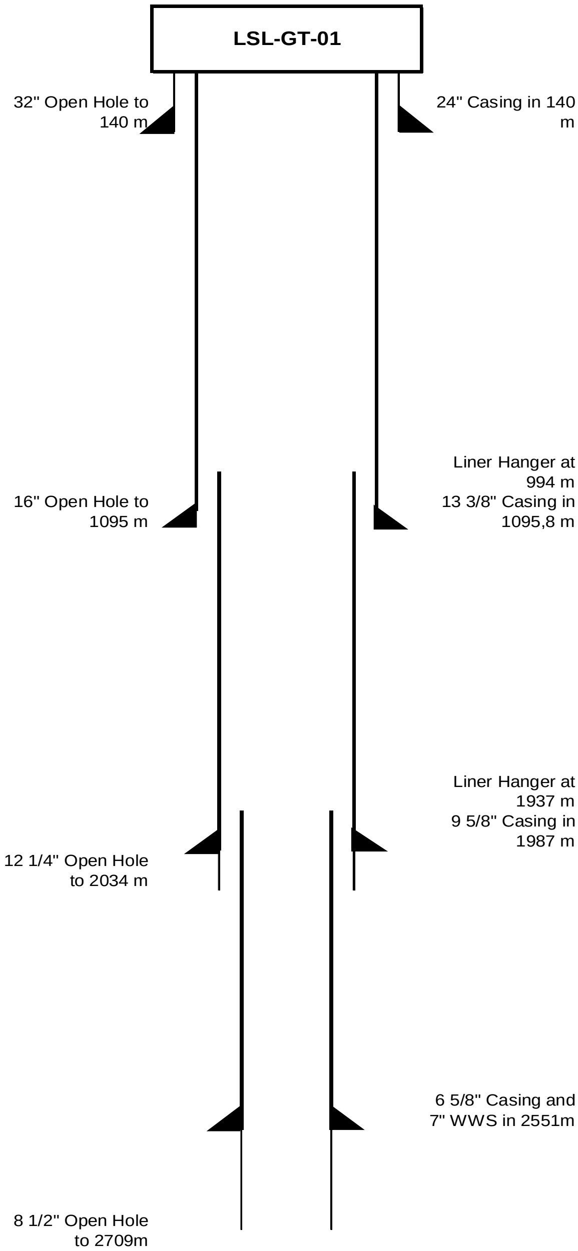

Figure 2: Well schematic of LSL-GT-01.

2.2 Drilling and Testing LSL-GT-02

The first section of LSL-GT-02 well (Fig. 3) was drilled with a 16” Tricone bit in combination with DHM and MWD/MWD-GR and drilled in rotary and sliding mode to 1136 m.

After hole cleaning the 13 3/8” surface casing was set, the casing shoe in 1130 m. The cement job was successfully completed and complete pressure test and installation of wellhead and BOP, install wear bushing was performed.

Make up 12 1/4" BHA and drilled in rotary and sliding mode to 2214 m section TD. Set 9 5/8” Casing and cement Casing with Casing Shoe at 2209 m and pressure tested 13 3/8” casing and 9 5/8” liner with success.

The third section started by picking up new 8 1/2” BHA and continue drilling in sliding and rotary mode to 2860 m (TD). The installed 6 5/8” blanks and 7” wire wrapped screens completed this section with a casing shoe depth of 2858 m.

A short well test with installation of an ESP string and build up phase have been performed within 4,5 days. The maximum measured flow rate was 370 m^3/h and the maximum temperature was 57°C.

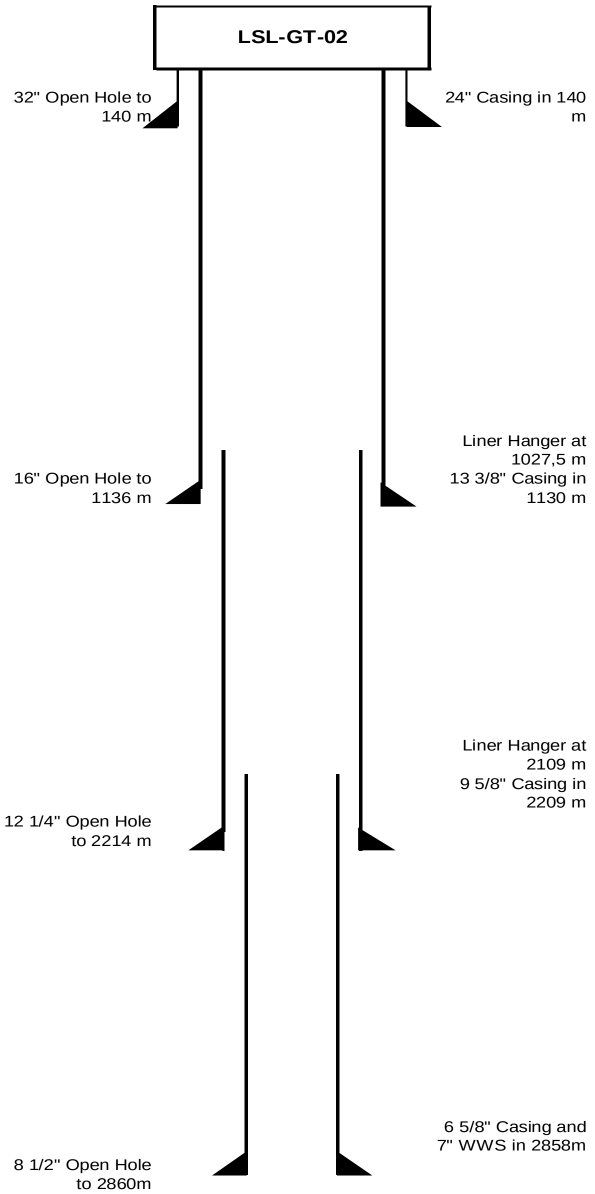

Figure 3: Well schematic of LSL-GT-01.

3. CONCLUSIONS

Due to the detailed technical review of the general contractor and implemented technical optimization as well as risk mitigation and contingency planning of the project management the doublet was executed in budget with reduced risk portfolio and consequential cost savings.

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