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Geothermal cascade use at Geinberg, Austria

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ABSTRACT

Situated in the Upper Austrian Molasse Basin Geinberg was one of the first geothermal projects in Austria. Based on the well "Geinberg **1**" hot water from the Malm aquifer was used since early **1980** for geothermal purposes. Legal aspects and growing demand for thermal water showed the necessity of a second well, to complete a geothermal doublet. This new well "Geinberg Thermal **2**" was planned as a deviated well situated in the vicinity of the existing old well "Geinberg **1**" with a distance between the withdrawal and reinjection in the carbonate deep-groundwater aquifer of some **1,600** m. The drilling started as a vertical drilling to a depth of **600** m. Using a top drive device deviational drilling was brought to the total depth of **3,155** m MD **(2,225** m TVD) in **52** days.

Quarternary, Tertiary and Upper Cretaceous sequences were penetrated before entering the thermal reservoir in the carbonate rocks of Malmian age at **2,910** drilling meters. After acid stimulation and testing the regular geothermal production started at **22''** of December with a free overflow of app. **20** l/s. The outflow temperature is in the order of 100 °C. The established geothermal cascade enables the use of a temperature interval of a maximum of **70** °C, which equals a thermal output of app. **5.8** MW. The reinjection temperature reaches a minimum of **30** °C thus allowing the reinjection without pressure. As backup heating is needed the return temperature of **30** "C is independent of the outside temperature. Geinberg is the first geothermal plant in Austria to perform cascade use. Further thermal **use** including heat pumps are intended.

KEYWORDS

Geinberg, Upper Austria, Molasse basin, deviated well, geothermal cascade **use**

1. Introduction

Geinberg, situated in the Upper Austrian Molasse Basin close to the German border (figure 1) was one of the first geothermal projects in Austria. Based on an abandoned hydrocarbon exploration well ("Geinberg 1") hot water from the Malm aquifer was used since early 1980 for geothermal purposes covering district heating, cooling use in a dairy and heating of a greenhouse.

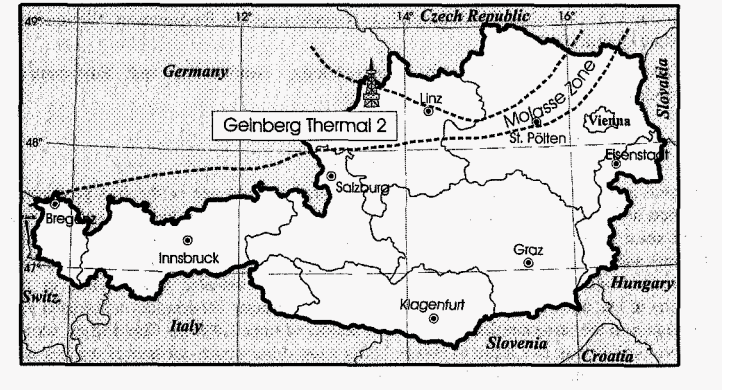

Figure 1: Location of well Geinberg Thermal 2 within the Upper Austrian Molasse Basin

Water-legal aspects (demand of reinjection of thermally used water to ensure a constant reservoir pressure) and the decrease of pressure together with the growing demand for thermal water showed the necessity of a second well, to complete a geothermal doublet.

Vamed AG as the main proposer submitted the project in the context of the European Union Thermie A Program. The project was accepted by the European Union to be eligible for promotion and included drilling of a second well and the improved and enhanced use of geothermal energy in a thermal cascade covering the temperature range between 100 °C and approximately 30 °C. Geoteam SA acting as a project partner took the responsibility for geological and hydrogeological planning, the technical design of the drilling and the project-management of the drilling and testing program.

The new well "Geinberg Thermal 2" was planned as a deviated well situated in the vicinity of the existing old well "Geinberg 1". To prevent a hydraulic shortcut the necessary distance between the withdrawal and reinjection in tbe carbonate deep-groundwater aquifer is some 1,600 m.

The successful drilling of the well Geinberg Thermal 2 forms the basis for the enhanced use of geothermal energy involving also balneological use in a new built spa and a hotel complex as one step in the geothermal cascade, which enables an optimal energy output.

2. Drilling operation

2.1. Drilling data

Drilling was performed using a contractor rig **IDECO** SBS H900 with a hook load capacity of 225 t. Use of top drive device for directional drilling ensured fast and **secure** operation during drilling, piping and cementing.

Spud date:	July 7th 1998
Total depth reached	August 27th 1998
duration of drilling operation:	52 days
Total depth:	MD: 3,155 m; TVD: 2,225 m

MD = measured depth, TVD = true vertical depth

BOREHOLE DIAMETER

Top (MD) [m]	Bottom (MD) [m]	Bottom (TVD) [m]	Drilling Diameter
surface	602.0	602.0	17 1/2"
602.0	1,756.0	1,514.7	12 1/4"
1,756.0	2,880.0	2,106.0	8 1/21'
2,880.0	3,155.0	2,225.0	6 1/8"

CASING LOCATIONS

Top (MD) [m]	Bottom (MD) [m]	Casing diameter
surface		drive pipe, 18 5/8",96.5 lbs/ft, J 55
surface	599.24	conductor casing, 54.5 lbs/ft, J 55, Buttress threads, cemented to surface
surface	1,755.40	intermediate casing 9 5/8", 40 lbs/ft, J 55, long thread couplings, cemented to surface
1,685.64	2,879.50	liner 7", 23 lbs/ft, N 80, Buttress threads, cemented up to the liner hanger @ 1,685.64 m
2,879.50	3,155.00	open hole 6 1/8"

2.2. Drilling program

The drilling of Geinberg Thermal 2 started at July 7th 1998 (execution: OMV PROTERRA), after 5 days a depth of 602 m was reached (17 1/2" drilling section). The conductor casing 13 3/8" was set at a depth of 600 m (figure 2).

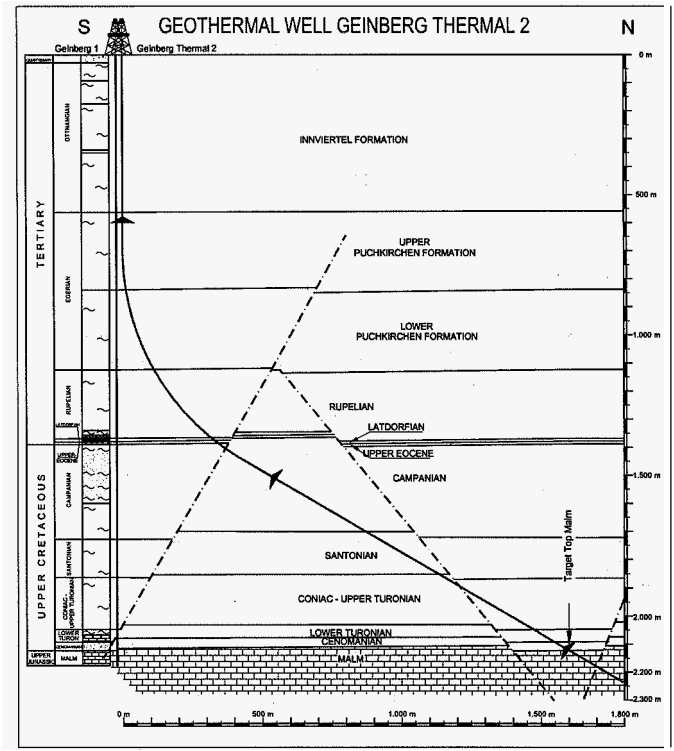

Figure 2: Deviated well Geinberg Thermal 2, geological profile

In this vertical section a deviation of only 1° was proofed by Single Shot measurements and wireline logging. After execution of geophysical borehole logging, casing job and cementation (13 3/8" conductor casing), the drilling of the 12 1/4" drilling section started. The kick-off-point for deviational drilling using a turbine was situated just below the casing shoe (figure 2). The use of top drive device enabled an acceleration of the drilling progress and shorter handling times. Deviation was directed towards North (azimuth 394.95" - 4.4°) at an angle of deviation of max. 64.4" (figure 2).

After reaching the final depth of the 12 1/4" drilling section at a depth of 1,756 m MD, the intermediate casing 9 5/8" was set to seal off the unstable tertiary formations (especially in the Rupelian formation) which have been regarded critical concerning the stability of the deviated hole.

The section to the top of the productive formation (1,124 drilling meters) was drilling with a bit diameter of 8 1/2" within 13 days (Final depth of the 8 1/2" section: 2,880 m MD). The shoe of the casing was set in the Cenomanian sandstones thus avoiding possible mud losses in the fractured limestones of the reservoir. This section was finished with the installation of a 7" liner, which was cemented.

The thermal reservoir was drilled with a diameter of 6 1/8" to the total depth of 3,155 m MD (2,225 m TVD). Top Malm was reached at 2,910 drilling meters (2,117 m TVD). By keeping the mud weight at 1.1 kg/l heavy mud losses have been avoided.

In the 12 1/4", 8 1/2" and 6 1/8" section predominantly PDC (polycrystalline diamond compacts) bits were used which ensured acceptable penetration rates (maximum: 250 m/d).

During deviational drilling azimuth and inclination were continuously recorded by MWD (measuring while drilling). Therefore it was possible to steer the drilling at any time and correct it according to planning. The landing point of the deviated well Geinberg Thermal 2 represents the accurate target. Geophysical measurements were performed as LWD (logging while drilling) recording natural gamma ray. These measurements enabled the stratigraphic correlation with the existing well Geinberg 1.

3. General stratigraphy

The borehole began in the Quarternary and penetrated 1,468.5 m (MD) Tertiary sequences before entering the more consolidated Upper Cretaceous sediments which overly the geothermal reservoir in the carbonate rocks of Malmian age (see figure 2). The top of the carbonates was reached at a depth of 2,910 m MD (2,120 m TVD) at a distance of 1,540 m from the surface location. Malm carbonates (mainly dolomites) persisted to the end depth of 3,155 m MD (2,225.45 m TVD, horizontal displacement = 1,761 m). The geological sequence of the well Geinberg Thermal 2 is shown in table 1.

At 1,577 m MD a fault was reached in the Campanian sequence (figure 2). This was proved by slow drilling progress, the occurrence of polished fault surfaces on cuttings and CO_2. A second fault was reached at 2,658 m MD, which induced a bigger Coniac-thickness. At

3,100 m MD a third fault was reached, which was proofed by the occurrence of lower Malmian rocks in a higher position.

MD [m]	TVD [m]	Lithostratigraphy		Thickness MD [m]
34.0	34.0	Quarternary - Terrace		34.0
558.0	558.0	Innviertel Formation (Miocene)		524.0
835.0	835.0	Upper Puchkirchen Formation (Oligocene)		277.0
1,113.0	1,108.0	Lower Puchkirchen Formation (Oligocene)		278.0
1,468.5	1,352.5	Rupelian (Oligocene)		355.5
1,411.0	1,320.5		Shale Stage	298.0
1,454.0	1,344.5		Banded Marl	43.0
1,468.5	1,352.5		Light Marly Limestone	14.5
1,484.5	1,361.0	Latdorfian		16.0
1,502.0	1,371.0	Upper Eocene		17.5
1,497.0	1,368.5		Nullipora Limestone	12.5
1,502.0	1,371.0		Sandstone	5.0
2,910.0	2,117.0	Upper Cretaceous		1,408.0
2,100.0p	1,704.0		Early Campanian	598.0
2,353.0	1,845.0		Santonian	253.0
2,747.5	2,048.0		Coniac - Upperturonian	394.5
2,835.0	2,087.0		Lowerturonian	87.5
2,910.0	2,120.0		Cenomanian	75.0
ET 3,155.0	2,225.0	Upper Jurassic - Malm (Dolomites)		245.0

4. Acid stimulation, testing and hydrochemistry

After cleaning up the hole a first test with air lift pump was started at the beginning of September 1998 which showed a maximum production rate of app. 18 l/s. Pressure and temperature were continuously recorded at a depth of 402.67 m below ground level. To enhance the production an acid stimulation using a total volume of 60 m^3 of hydrochloric

acid (15 %), acetic acid (6 %) and citric acid (1 %) was performed. The acid was pumped through a coiled tubing string which allowed movement of the string during stimulation. After stimulation the production using air lift pumping reached a maximum of 50 l/s at a temperature of approximately 100 °C.

Free overflow of the well was enhanced by changing the well head design to approximately 20 l/s. Reinjection tests using well Geinberg Thermal 2 as production and Geinberg 1 as reinjection well were started at October 19th 1998. At a flow rate of 30 l/s a maximal flowing pressure of 1.9 bar was encountered at the well Geinberg 1 thus proofing the suitability of the well for reinjection.

Chemical investigations showed that air lift pumping provokes precipitation of carbonates which could be dangerous for the technical installation. Therefore the reinjection test was performed at the free overflow rate of well Geinberg Thermal 2. During test the production was already used for geothermal purposes and use of the water in the new spa and the hotel complex.

Hydrochemical analysis showed, that the deep groundwaters from wells Geinberg Thermal 2 and Geinberg 1 are nearly identical. They are of the "Sodium-Bicarbonate-Chloride-Sulfur"-type with a TDS of 1.1 g/kg.

5. Geothermal production

Testing operation ended at the beginning of December 1998. After changing the well head design by lowering the outflow point to a level of app. -2 m below surface and installation of a degassing tank free overflow reached a value of app. 20 l/s. The regular geothermal production started at 22nd of December.

The outflow temperature is in the order of 100 °C. The cascade use - industrial processes in a dairy, district heating in the village of Geinberg and the thermal resort and spa of Geinberg, use of water in the spa and greenhouse heating - enables the use of a temperature interval of a maximum of 70 °C, which equals a thermal output of app. 5.8 MW (figure 3). The reinjection temperature reaches a minimum of 30 °C thus allowing the reinjection without pressure. As backup heating is needed the return temperature of 30 °C is independent of the outside temperature.

The successful drilling of the deviated borehole Geinberg Thermal 2 forms the basis for geothermal use with a geothermal doublet. For the doublet the new drilled well Geinberg Thermal 2 will be used as the production well, the existing well Geinberg 1 will be used as the reinjection well. Geinberg is the first geothermal plant in Austria to perform the cascade use. Further thermal use including heat pumps are intended.

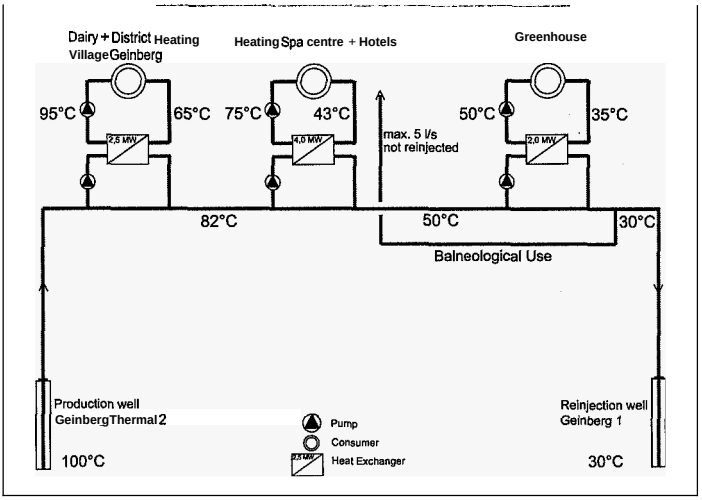

Figure 3: Cascade Use of Geinberg

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