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Geothermal Drilling for Space Heating in the Town of Szentlőrinc in SW Hungary

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ABSTRACT

The area in the vicinity of town Szentlőrinc, SW Hungary, was evaluated in respect to geothermal energy and the first drilling took place from April to September 2009. Extensive quantity of existing geosciences data is available for the area and has been used to site the first well for utilization of geothermal water for space heating in the vicinity of the town. The data that has proven to be of the most value is geological data from existing wells along with temperature measurements in these wells. Four seismic lines exist in the area gave valuable information on the geology and depth to the expected reservoir and locations of promising fault zones. To strengthen the interpretation of the geosciences data an AMT/MT and gravity survey was conducted in 2008 in an attempt to find zones with higher porosities and permeability. Based on thorough analysis of available data well site was chosen with the aim of penetrating major fault zones within the basement indicated by seismic data, where the AMT/MT and gravity results imply potential geothermal zone, and where wells indicated favorable temperature and reservoir rock type. Due to technical reasons the drilling took longer time than expected. The well was successfully finished giving 20 l/s in airlifting of over 80°C hot water with 5–10 l/s of artesian flow. The geothermal energy will be used in the local district heating system.

1. INTRODUCTION

The first well, Sztl-PE-01 has been drilled in the vicinity of the town Szentlőrinc, SW Hungary that had previously been evaluated in respect to geothermal energy (Figure 1). The well site was a conclusion of the second phase in a large project that has been ongoing since the fall of 2006 with the aim of locating possible well sites for geothermal utilization in Hungary. The objective was to find geothermal reservoir that could be used to produce electricity and/or for space heating. The well location was proposed based on existing and new geosciences data from Hungary. The new data is the extensive AMT/MT and gravity surveys performed by KMS Technologies for Mannvit.

This article outlines the methods used for selecting well site close to Szentlőrinc and the results of the first well.

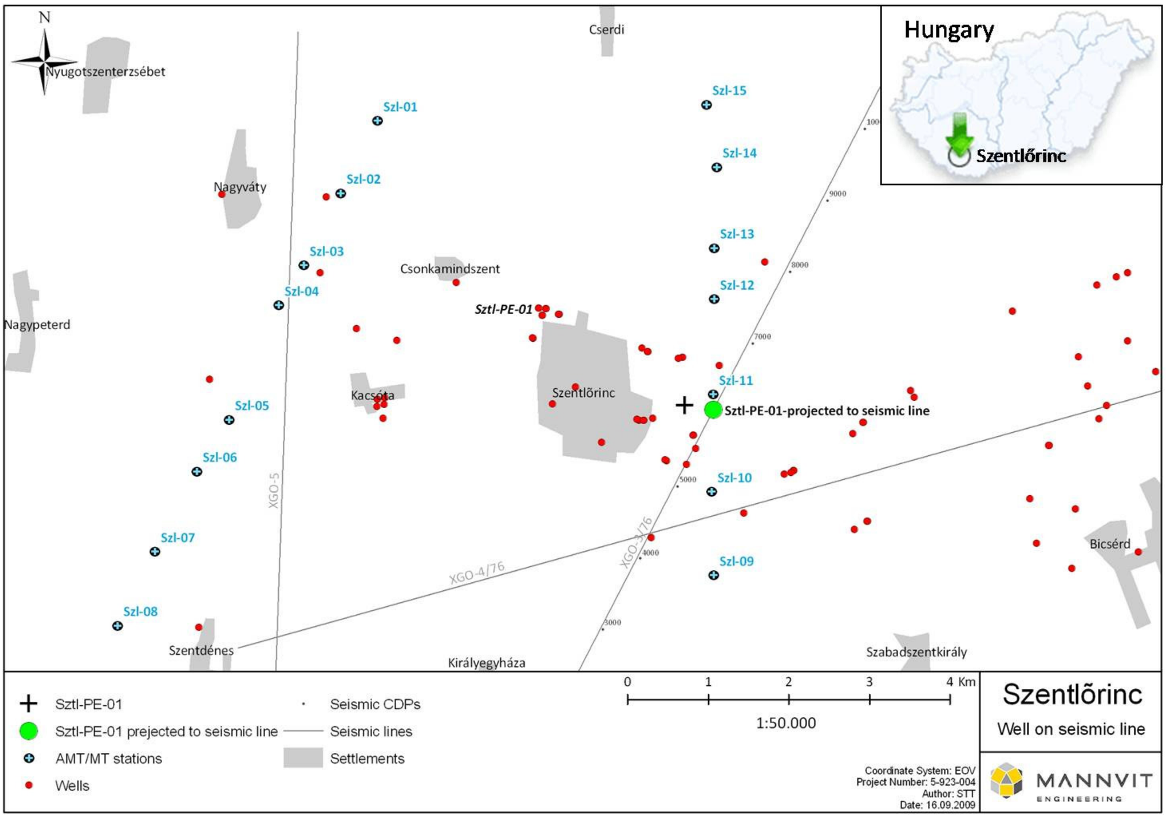

Figure 1: Szentlőrinc, location of the AMT/MT and gravity survey lines, seismic lines and the wells in Szentlőrinc.

2. GEOLOGICAL SETTING

Hungary is situated in Central-Europe in the Pannonian Basin. The Danube River cuts through the country separating it into two main parts: the Transdanubian Central Range with Lake Balaton in the northwest and the Great Hungarian Plain in the east and south.

Geographically, Hungary is positioned in the middle of the Pannonian Basin. The Pannonian basin is comprised of higher thermal conductivity Precambrian-Paleozoic-Mesozoic basement rocks and is filled with lower thermal conductivity Cenozoic sediments. According to thermo-tectonic models the initial crustal thinning or rifting of the Pannonian basin occurred in the Middle Miocene and the subsequent thermal subsidence or post-rift phase extended up to the present (Royden et al., 1983a and b; Royden, 1988). The Pannonian sediments are multilayered and comprised of sand, shale, and silt beds. While the lower Pannonian sediments (e.g., clay, silt, marl) are impermeable (aquicludes), the upper Pannonian and Quaternary formations contain vast sand and sandstone beds of upper Pannonian age which are porous and permeable (Bobok et al., 1998). Significant strike slip movements along the basement rocks have caused high secondary porosity and along some tectonic lines, high pressure geothermal conditions were generated (Árpási, Lorberer, and Pap, 2000; Tóth and Almási, 2001).

Szentlőrinc is located in SW Hungary in a region where faults are abundant generally with W-E direction. Commonly, the faults are strike slip faults with compressional and/or extensional component. The main part of the basement is crystalline rock belonging to the regionally known Baksa Complex. In general, this complex consists of the alteration of low, medium and high grade gneiss and mica-shist that is slightly folded. Amphibolite, leptinolite, marble and dolomitic marble intercalation are present, with regional metamorphic calcareous silicate rocks it the underlying of the dolomitic marble. Locally dolomite/limestone of Mesozoic age is observed, though more known in the mountains where it outcrops north of the town (Csontos et al., 2002a and b; Császar, 1997; Fülöp and Dank, 1987).

3. METHODS AND RESULTS USED TO LOCATE THE WELL

Well sites in the vicinity of the town Szentlőrinc were chosen by an integration of well data, seismic data, AMT/MT and gravity data (Figure 1). Along with these data sets related articles and maps were also studied (e.g. Waterplan Kft., 2006; Csontos, 2002a and b; Fülöp and Dank, 1987; and Wéber, 1977). Below the main method and results are outlined but detailed description of the methods are given in Helga Tulinius et al. (2010) and Yu et al. (2009).

3.1 Well Data

Data from existing wells gave information on the temperature distribution of the region and extent of certain lithological units. Numerous wells have been drilled around Szentlőrinc; mostly shallow wells (100 - 500 m depth). A few wells deeper than 400 m were of the most importance in this study as the aim was to gain knowledge about the stratum below 400 m depth. The deepest well within the development area was 911 m.

The temperature indicated by well data implied the that temperature of 80-100°C, that is enough for district heating purposes, would be reached at about 1,300 -1,700 m depth. Temperature of 66°C in a 911 m deep well was the highest temperature observed in the wells close to Szentlőrinc (Figure 2).

Lithological layering below about 900 m down to where the temperature was expected to be of interest was uncertain. A few wells indicated dolomite/limestone of Mesozoic age to be found in the region but at shallower levels than of interest to this project. Thus, it was uncertain whether the most favorable reservoir characteristics of Triassic dolomite/limestone formation would persist at the depth of interest to this project. It was even likely that a Paleozoic crystalline basement would be penetrated (Figure 2).

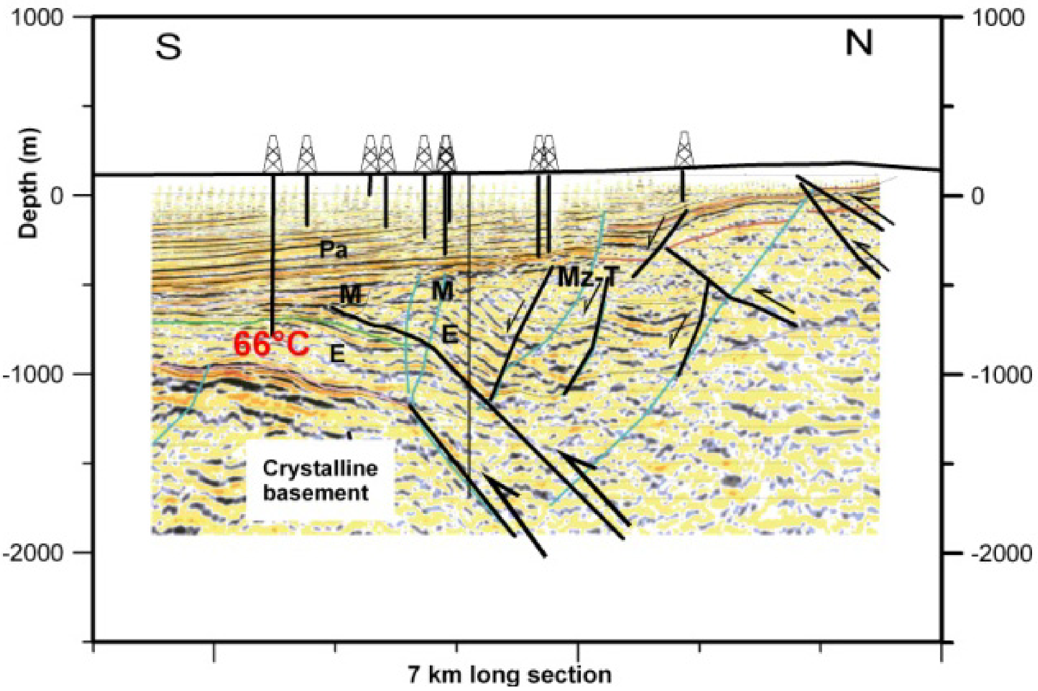

Figure 2: Seismic line GÖ-3 with existing wells, west of Szentlőrinc.

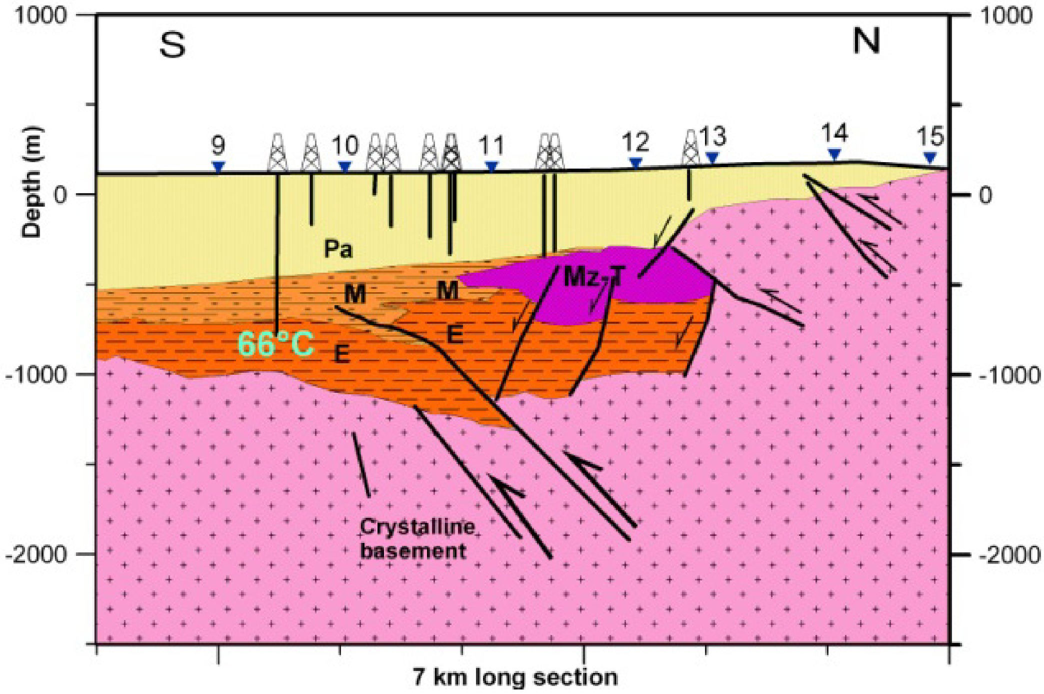

Figure 3: Geological cross section along AMT/MT and gravity line 2 in Szentlőrinc.

3.2 Seismic Data

Total of four seismic profiles were available for this study. The seismic data was used to trace the lateral extent of certain rock types and to locate fault zones within the layers. The seismic data indicated the region to have undergone major tectonical movements during its geological history (Figure 2). The major fault zones of the region are reverse faults that have W-E direction and are dipping towards the north. Smaller normal faults were also detected giving rice to the conclusion of the region to have experienced compressional as well as pull-apart mechanism. There are possibilities of the region to be seismically active at present as there was an earthquake detected close by in late year 2006.

3.3 AMT/MT and Gravity Data

Two AMT/MT and gravity lines were measured in the vicinity of Szentlőrinc with the emphasis of locating potential geothermal zones where low resistivity and low gravity anomalies were observed. AMT/MT line 1 with stations Szl-1 to Szl-8 is located west of the town and AMT/MT line 2 is east of the town with stations Szl-9 to Szl-15 (Figure 1).

Potential geothermal zones were indicated by AMT/MT and gravity data in both of the survey lines. In line 2 the low resistivity anomaly was at deeper levels in the basement (Figure 4) than in line 1 that indicated possibilities of higher temperature in the vicinity of line 2 than line 1. Therefore, the potential geothermal zone in line 2, east of Szentlőrinc was considered to be more promising than west of it (Figure 1 and Figure 4).

3.4 Proposed Well Sites

Areas, with low resistivity and low gravity anomalies, outlined by AMT/MT and gravity data, that included promising structural and stratigraphic features, i.e. both fault zones (seismic) and/or dolomite/limestone (well data), was considered to be the most promising geothermal zones. The conclusion of the data evaluation process was the proposed well sites within the Szentlőrinc region indicating the western part to be more promising.

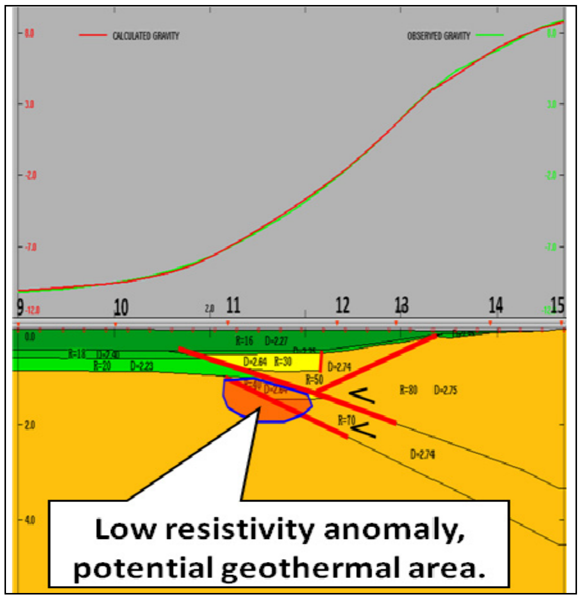

Figure 4: Inversion and interpretation of AMT/MT and gravity survey line 2 in Szentlőrinc.

4. WELL SZTL-PE-1

The first well in Szentlőrinc is located west of the town and close to a seismic, AMT/MT and gravity survey lines (Figure 1 and Figure 5). The drilling started in February 2009 and was completed in September 2009 at 1820 m depth.

During drilling of the well, some technical problem delayed the drilling. The well had to be cased 4 times (plus the surface casing) and the last one reaches 1613 m depth. The drilling was carefully monitored, but this is the first well to be drilled for geothermal purposed so deep and aiming for permeability in fractured crystalline rock.

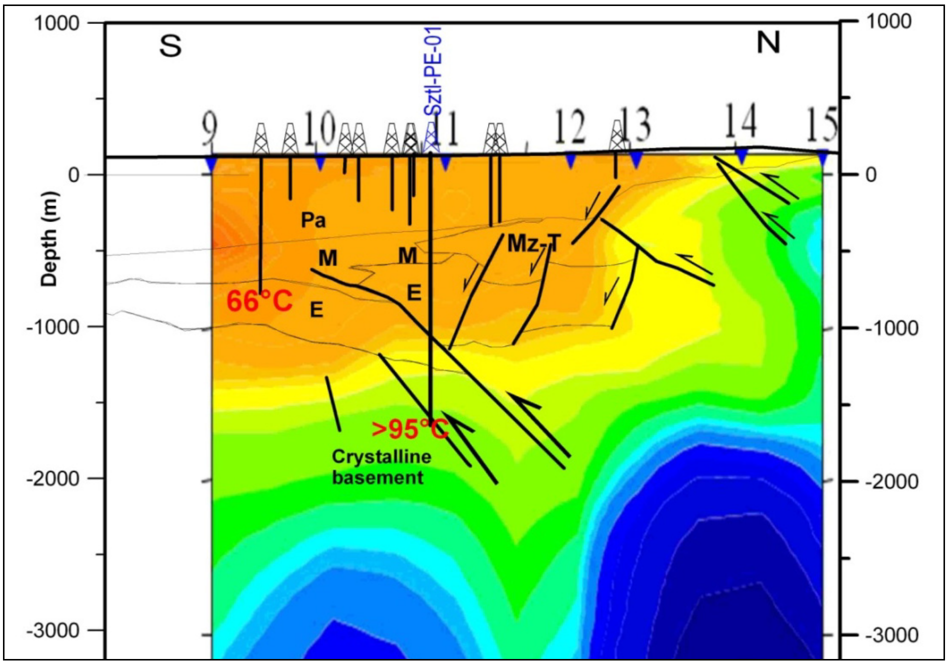

Figure 5: AMT/MT inversion with geological cross section and the well SZTL-PE-01. Well total depth is 1820 m. For location see Figure 1.

The surface casing (23") of the well is down to 20 m depth and then anchor casing (17 ½") is down to 447 m to prevent potential gas leakage into the well. A 12 ¼" production casing reaches down to 983.1 m depth and seals off a zone of swelling clay. A casing of 8 ½" bit size is down to 1613 m depth and then a perforated liner (6") is in the production part of the well down to 1820 m depth.

The geology was also carefully monitored and many well logging were performed. Several temperature logs, along with caliper and natural gamma exist in the well giving good indication as to where the feed points are in the well. The lithological log, porosity (neutron), density, resistivity and sonic logs help greatly in analyzing the formations drilled through.

4.1 Lithological Log and Temperature

The production part of the well is within fractured crystalline rock that belongs to the Baksa Complex. The crystalline basement was reached at 1330 m depth. From there and down to the bottom of the well several feed points can be seen in the temperature, caliper and sonic logs. The well is cased down to 1600 m depth and slotted liner is from there to the bottom. The biggest feed point is from 1700–1760 m depth, but several other feed points can be seen in the well.

Based on the wells in the area (all shallower that 1000 m) the average temperature gradient is 57°C/km. This means that the estimated temperature at the deepest big feed point (1760) was 110°C.

In the end of September 2009 the maximum temperature measured in the well was 95°C, and increasing. The expected outflow temperature is estimated to be over 90°C and from the airlifting period it is estimated that 20 l/s can be produced from the well in the future for space heating in the town of Szentlőrinc.

The lithological units penetrated by the well belong to the Cenozoic, Mesozoic and Paleozoic Eras (Figure 6). The Cenozoic layers (Pannonian (Pa), Miocene (M) and Eocene (E)) are mostly clastic sediments and sedimentary rocks. The Mesozoic (MZ) consists of limestone with clay intercalations and the Paleozoic (PZ) part is metamorphic rock (gneiss and mica-schist).

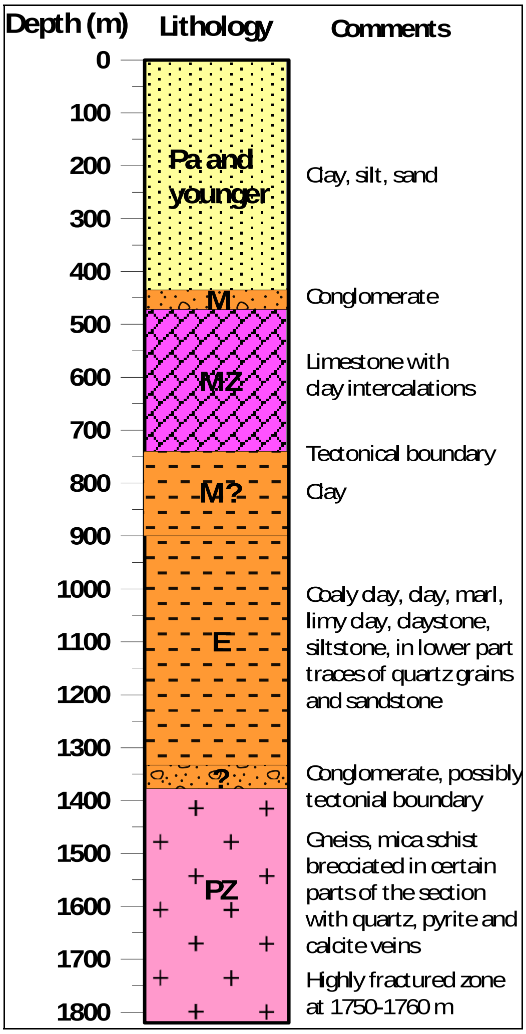

Figure 6: Lithology of well Sztl-PE-01.

The layers in the well indicate tectonic events to have occurred. Miocene layers are inserted by Mesozoic layers in the upper part of the well. Furthermore, major tectonical boundary is implied by conglomerate where the contact of Eocene and Paleozoic layers is present. The basement is brecciated in certain intervals and highly fractured zone is at the depth of 1750–1760 m.

In the fractured depth intervals in the basement secondary minerals, quartz, pyrite and calcite, are observed in the well. The veins clogged up with secondary minerals are 1–3 mm thick.

4.2 Well Testing

The well is artesian with 5–10 l/s flow. With airlifting over 20 l/s was produced from the well with over 80°C hot water for several days. The final well test will be performed in October 2009.

5. CONCLUSIONS

The first well drilled close to the small town Szentlőrinc in south Hungary reached 1820 m in early September. The well is artesian with 5 l/s of up to 90°C hot water. During airlifting the well gave over 20 l/s of water. The well has not been tasted yet, but it produces mainly from a fault zone at 1700–1760 m depth in a crystalline basement. The next well will be drilled later in 2009.

The general hypothesis for geothermal utilization in Hungary is that the permeability is the best in fractured limestone/dolomite of Triassic age. When siting well Sztl-PE-01 no prove of limestone/dolomite was available at the depth of geothermal interest, but the existence of a major fault zone was evidence in the AMT/MT, gravity and seismic data. The reservoir penetrated by the well is in crystalline formation which proves that geothermal reservoirs can also be located in fractured crystalline basement in Hungary. This implies that the geothermal potential in Hungary is more than previously estimated.

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