Bulletin d'Hydrogéologie No 17 (1999)
Centre d'Hydrogéologie, Universitd de Neuchritel
EDITIONS PETER LANG

Steam-productive wells in south-eastern part of Hungary

by Sándor Pap

The Hungarian Geothermal Association Inc., Ady E. u. 26, H-5001 Szolnok, Hungary

ABSTRACT

Hungary has a favourable geothermal position with regard to the geological conditions. The reason is the thinning of the crust and the lithosphere below the Pannonian Basin. Because of this the convection and the geothermal gradient are higher than the world average. The basin parts of Hungary were filled by Neogene sediments with relatively poor thermal conductivity. The Precambrian-Paleozoic-Mesozoic rocks, which have been found deeper (in some places at the depth of 7000m) can be caracterized as having different thermal conductivity. For this reason and because of the convection the temperatures of the Neogene basement rocks are different. From the basement rocks - from relatively low depth- we *can* get wet-steam production. The most suitable rocks for steam production are the carstificated formations and the brecciated rocks of the tectonic zone and its surroundings The reservoir pressure may be twice as much as the hydrostatic pressure. The practical proof are the four steam-productive wells in South-East part of Hungary which were drilled in the programme for oil and gas exploration. The exploration activity has continued since the 1920's in the Great Hungarian Plain. These wells are: Tótkomlós (T)-14, Almosd-13, Nagyszénás (Nsz)-3, Fábiánsebestyén (Fáb)–4.

KEYWORDS

Pannonian Basin, geothermal energy, wet-steam production, high enthalpy reservoir

Introduction

Hungary has a favourable geothermal position with regard to the geological conditions. The Precambrian - Paleozoic - Mesozoic rocks, which have been found deeper can be characterized as having different thermal conductivity values. From the basement rocks, at a relatively low depth, we can get wet-steam production. The practical proof is presented by the four steam-producing wells in south-east part of Hungary. The wells are described in order of the drilling (figure 1).

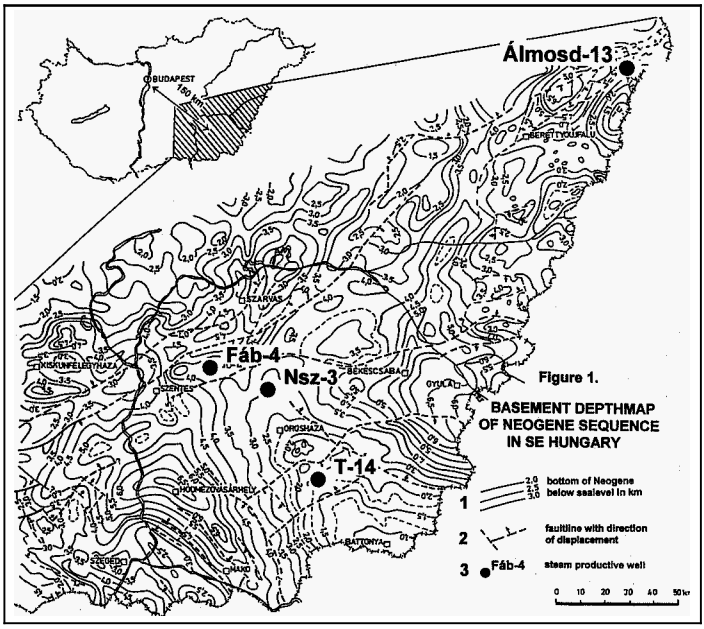

Figure 1: Isobath map of the base of the Neogene sequence in SE Hungary

Tótkomlós(T) -14 well

This well was drilled in 1958, and was the first well in Hungary which produced steam. The result of the open-hole test (between 1579.5-1634 m) through 2 1/2" tubing was an unknown amount **of** steam with a little gas and water at 95 °C. During the production the pressure was 0.34-0.39 MPa. After closing the well the pressure increased to 1.96 MPa, but then decreased to 0.51 MPa. The site of this well is in a zone of 10-12 km width, NE-SW strike direction and consists **of** Mesozoic rocks. This area is known as one of the hight enthalpy geothermal reservoirs in Hungary. The thickness of this zone can be even 2000 m at some places and it consists of sandstone, dolomite, limestone, marl and shale. The best reservoirs are the hydrodynamically partly isolated Middle-Triassic brecciated dolomites.

The porosity of these rocks is 4-8 %, the permeability may reach 800-1000x10" μm^2 values. The geothermal gradient near the well is 72-73 °C/km, but further at the outcrop of the zone is 55-65 °C/km.

Álmosd -13 well

This well was drilled in 1981, and opened a fractured zone in the metamorphic rocks between 3278-3280 m. It produced 360 m^3/d water (93°C) and some gaseous-steam. The diameter of jet was 7.4 mm. The gas-to-steam ratio could not be determined. Calculating separately the amount of steam (relative density 0.622) was 2990 m^3/d, and the amount of gas (relative density 0.995) was 24100 m^3/d. The production pressure was 12.9 MPa, and the pressure in the reservoir was 48.035 MPa. During the production the temperature of the fluid was 143°C at a depth of 2500 m.

The total amount of salts is 19,565g/l, and the water is of NaCl-type. The gas, which was produced together with the water, is up to 55,97% combustible gas, the CO_2 content is 38,28% and the N_2 portion is 5,75%.

In the metamorphic basement of Álmosd the average geothermal gradient is 51°C/km, which corresponds to the countrywide common value. The pressure is different in the separate rock-blocks, somewhere it is hydrostatic, but at certain places the overpressure is 80% or more. This proves that there are blocks which are separated hydrodynamically. The reservoir capacity of the metamorphic rocks is generally 1-2%, the permeability is minimal. The reservoirs which produce great inflow are the reverse fault zones and the brecciated rocks in their sorroundings (figure 2). In these cases the reservoir capacity can be much more, and the permeability can be a hundred times higher. By opening the reverse fault zones inside the blocks a dry-hot style circulated energy production could be established at that field.

Fábiánsebestyén (Fáb)-4 and Nagyszénás (Nsz)-3 wells

The wells were drilled near the tectonic zones which separate the Villány-Bihar and the Szeged-Békés Mesozoic structural units. The depth of the basement, the litbological structure and the main tectonic zones can be seen on the figure 3. The oldest formations which were drilled by wells are gneiss and mica-schist. Permian consists of by quartz porphyry. The lower Triassic fluvial claystone-sandstone-conglomerate beds were penetrated by Nsz-3 and Fhb-4 wells. Oros-2 and Fhb-4 wells crossed the Middle-Triassic brecciated dolomite. In the middle of the region, on a relatively narrow band with NE-SW strike direction Upper Cretaceoous sandstone layers overlay on the Triassic formation. Two of the wells in that are produced steam-in-flow.

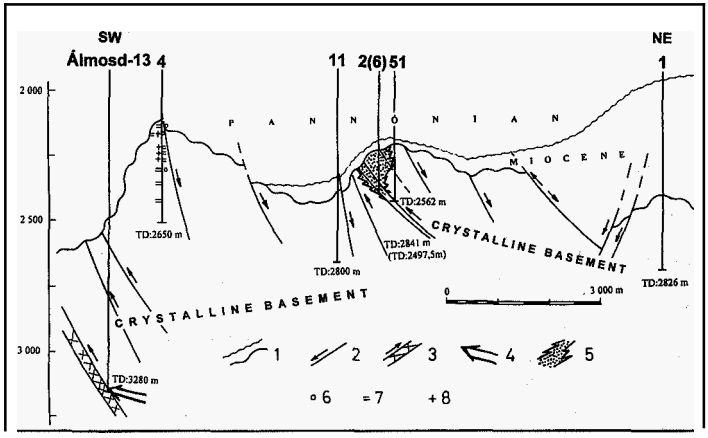

Figure 2: Sketchy geological profile by means of Metamorphic structure of Almosd. Legend: 1. discordance surfaces; 2. tectonic face with dislocation direction; 3. reverse fault with brecciated zone: 4. inflow of hot-water- steam in Álmosd-13 well; 5. brecciated metamorphite infilled with gas. Testing results of Álmosd-4 well: 6. oil: 7. water; 8. gas.

Nagyszénás (Nsz)-3

This well was drilled in 1981. The drilling (between 2922-35OOm) crossed formations with different age, rock types and permeability. The result of the open-hole test was: 1891 m^3/d of water and 10060m^3/d of gas. The greater part of the fluid came from the Lower Triassic quartz-sandstone at the depth of 3165 m. The calculated reservoir pressure at the influx depth was 63.8 MPa and the reservoir temperature was 190 °C.

According to these the geothermal gradient is 57.23 °C/km and the overpressure is more than 100%. Considering chemical composition, the water has a high salt content, but has only carbonate hardness, thus it is a soft NaCl-type mineral water. It has considerable quantities of lithium and fluoride and belongs to the iodide-bromide-type of mineral waters. During the production scaling was observed in the pipes.

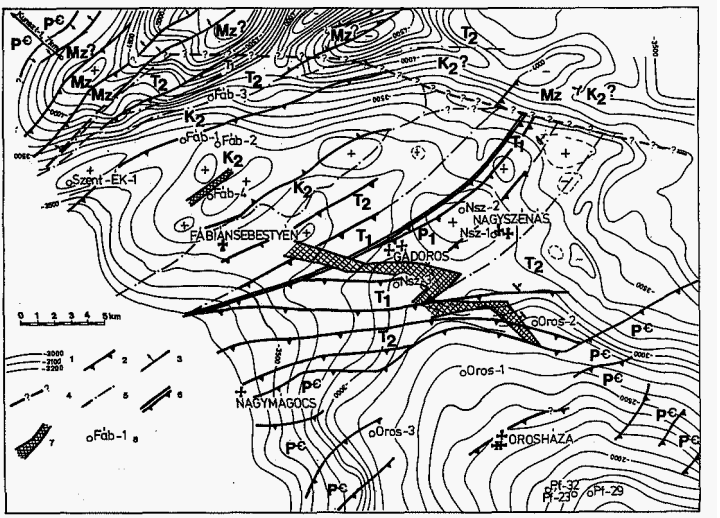

Figure 3: Subcrop map and isobaths of the Neogene base in the region Fábiánsebestyén, Nagyszénás and Orosháza. Legend: 1. depth of Neogene base below sea level; 2. overthrust zone; 3. normal fault; 4. tectonic zone of unknown character; 5. formation boundary; 6. regional thrust zone (boundary of Villány-Bihar and Szeged-Békés zones, and of the Alföld autochthonius and the South Alföld nappe); 7. deep tectonic zone; 8. hydrocarbon prospecting borehole; Pc:Precambrian-Palaeozoic metamorphites; P: Permian quartz porphyry; T_1: Lower Triassic sandstone and conglomerate; T_2: Middle Triassic brecciated dolomite; K_2: Upper Cretaceous clastic; Mz: Mesozoic formations in general.

Fábiánsebestyén (Fhb) -4 well

This well was drilled in 1985, near to an important tectonic zone. During the drilling steam blew out from the opened section (3698-4239 m). The blowout happened December 16, 1985 at 4.25 pm. The blowout had been active until January 31, 1986, 19.15 pm. It produced hot water (160°C) with steam (20%). The amount of fluid was 5000-8500 m^3/d. The production pressure at the surface was 36.0-37.5 MPa, occasionally 40.0 MPa. The estimated pressure at the bottom of the hole was 76.3 MPa and the reservoir temperature was 200-210 °C. The water-steam fluid entered from the section between 3750-4034 m in a

Middle Triassic brecciated dolomite intercalated with dolomite-marl. The total salt content of the water was 27.20g/l. The main component is NaCl, and the hardness of the water was high. The 47-day-blowout was the longest one (duration) in Hungary and because of its type was absolutely unusual. After pulling out, in the casing (9 5/8") the crust could he found down to 1167,5m depth. The thickness of the crust was 55mm at the surface, and decreased by the depth uniformly. At the depth of 980m it was only 20mm.

Among the already mentioned basement rocks only the brecciated dolomite reservoir and the brecciated tectonical zones - apart from the lithologies - produced such a large amount of steam-in-low like Nsz-3 and Fáb-4 wells. In order to determine the areas of geothermal reservoirs magnetotelluric measurements were carried out near both wells. On the base of the results show an irregulary shaped, high conductivity zone, which reaches to 9-10 km depth. This zone can be found NW to Fib-4 well, the strike direction is SW-NE, and North to Nsz-3 well, the strike direction is WNW-ESE. This is a hot -water reservoir with many types of brecciated rocks. In this reservoir the heat-convection and the water-flow rise, too.

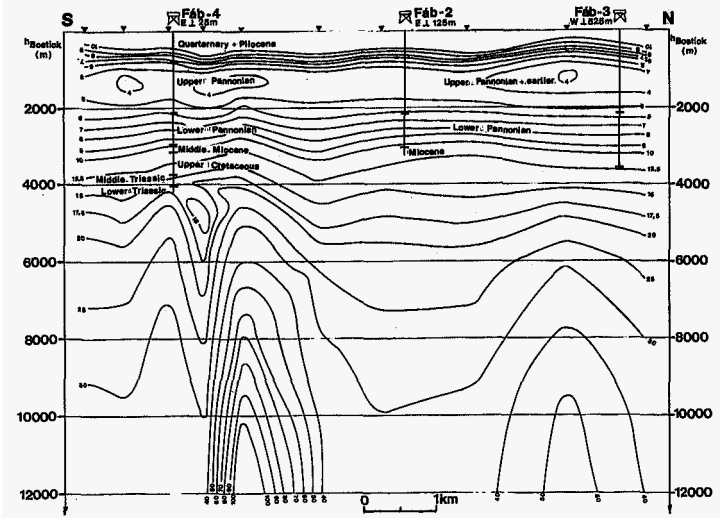

Figure 4: H-polarized, transformed afterBOSITICK resistivity log through Fáb-4 well (GY. HAjdú-Mrs. Landy-Z.Nagy, 1989).

The figure 3 shows the tectonic zones and the figure 4 shows the depth of the tectonical zone and the direction of current by means of the magnetotelluric sounding. The results concerning the area of Fábiánsebestyén-Nagyszénás- Orosháza are: the high pressure and high temperature hot-water basement reservoirs are the Middle-Triassic brecciated dolomite and the tectonic zones which reach to 10 km depth.

Table 1 shows the temperature of the basement and in the vicinity of it. The high tempererature waters - partly or completely - ascend to the reservoirs and the wells from deeper formations (5-6km in Fib-4 well,and 9-10 km in Nsz-3 well) than the drilling depths. These waters probably move along the tectonic zones from great depths. This is also proven by SiO_2 temperature measurements. In the Fib-4 well the bottom-hole (4239m) temperature was 202 "C, but the SiO_2 temperature was higher, 254 "C. This is a proof that the produced water partly migrated from 5-6 km depth. In the case of Nsz-3 well, the SiO_2 dissolved in the water at 193 - 199 °C.

There are some projects to utilize high enthalpy geothermal energy in the region of Fábiánsebestyén-Nagyszénás.

Table 1: Temperature data in the Pannonian Basin and in the region of Fábiánsebestyén-Nagyszénás.

Well	Depth	Temperature	Geothermal gradient	Age
	m	°C	°C/km	
Szentes-ÉK-1	2975	143,4	44,8	Pannonian
	3400	160	44,1	Upper Cretaceous
Fib-2	3259	162	46,6	Miocene
Fib-4	3160	166,4	49,5	Upper Cretaceous
	3864,5	190,5	46,7	Middle Triassic
Nsz-2	2911	165	53,3	Pannonian
Nsz-3	3200	169	49,7	Lower Triassic
	3500	176	47,4	Permian
Oros-1	2610	142,2	50,6	Pannonian
	2800	149	49,6	Precambrian
Oros-2	2810	162	54,1	Miocene
Oros-3	2771	160	54,2	Pannonian
	2942	167	53,4	Precambrian

Conclusion

The four wells presented prove that there are reservoirs in Hungary which produce high pressure and high temperature steam. They can be utilized for power generation. Only the complex utilization will be economical, because the investments are expensive, high-risk and the recovery time fairly long.

References

BENCSIK I., CSABA J., MEGYERI M. & PAP S. 1992. Wet vapour production possibility from the Nagyszénás-3. well. Kõolaj Gs Földgáz 25 (125)/7: 193-206.

HAJDÚ GY., Mrs LANDY & NAGY Z. 1989. 219.sz. Jelentés az Orosháza-Nagyszénás-Pusztaföldvár kutatási területen 1987-1989. Cvekben végzett mérésekrõl. Manuscript, Budapest.

NAGY Z , LANDY I., PAP S: & RUMPLER J: 1992. Results of magnetotelluric exploration for geothermal reservoirs in Hungary. Acta Geodaetica, Geophysica et montanistica Hungarica 27/1: 87-101.

PAP S. 1993. Subsurface geology of Fábiánsebestyén-Nagyszénás-Orosháza area. Foldtani Kozlony 123/1: 69-98.

STEGENA L., HORVÁTH F., LANDY K-né, NAGY Z. & RUMPLER J. 1992. High enthalpy geothermal reservoirs in Hungary. Foldtani Kozlony 122/2-4: 195-208.