Geothermics 39 (2010) 357–364

Contents lists available at ScienceDirect

Geothermics

journal homepage: www.elsevier.com/locate/geothermics

Utilization of geothermal systems in South-East Hungary

János Szanyi[a,*], Balázs Kovács[b]

[a] Dept. of Mineralogy, Geochemistry and Petrography, University of Szeged, Egyetem u. 2, Szeged, Hungary
[b] Dept. of Hydrogeology and Engineering Geology, University of Miskolc, Miskolc-Egyetemváros, Hungary

ARTICLE INFO

Article history:
Received 19 June 2009
Accepted 3 September 2010

Keywords:
Geothermal resources
Sustainability
Injection
Pannonian basin
Hungary

ABSTRACT

Thermal wells have been used in Hungary for over 140 years. As thermal water production has increased during the past decades, the pressure drawdown has increased in the geothermal systems of the Pannonian basin, showing that their sustainable management is lacking. The Hódmezővásárhely, Szeged, and Szentes case histories are presented, including the very first indications of stabilization and recharge of the Pannonian thermal aquifers, as a result of reduction of thermal water production. Sustainable production and overall resource management of geothermal systems in SE-Hungary can only be achieved by injection.

1. Introduction

Hungary is located in Middle-Eastern Europe, in the Carpathian Basin. It lies in a high heat flow area of the continent (Dövényi et al., 2002; Antics and Sanner, 2007), on the boundary of the African and European tectonic plates (Fig. 1).

Due to late plate tectonic events, subsidence of the area has resulted in the formation of a large sedimentary basin filled with deep sea sediments. The most intense subsidence was in the Pannonian Age. During the filling of the sedimentary basin, the sea became shallower and brackish; later it became isolated from the ocean (Pannonian inland lake); and finally dried out completely. At the location of the former sea and lake, a huge sedimentary basin up to 6000–7000 m thick, with high-porosity sedimentary sequences (Pannonian basin), remained (Fig. 2).

In Hungary, the earth's continental crust is rather thin (22–26 km) (Dövényi and Horváth, 1988) and is covered by low-thermal-conductivity formations. These conditions led to a high geothermal gradient anomaly (approximately 50 °C/km) with a heat flow of 90–100 mW/m^2 (Dövényi et al., 2002).

Two fluid flow regimes exist in the basin: an upper, gravity-driven flow system, and a deeper, pressure (overpressure)-driven system in the mainly fine, deep sea sediments and underlying formations. The most probable cause of the high overpressure [up to 10 MPa above hydrostatic pressure (confirmed by deep drilling)] could be the tectonic compression of the formations (Tóth and Almási, 2001), though gas formation during the maturation process of sediments could also be a factor. At the bottom of the basin are both metamorphic and carbonate rock bodies that are of geothermal interest.

The porous formations of the Pannonian basin contain water up to 130–150 °C due to the high geothermal gradient; however, some karstified and fractured carbonated aquifers in the basement with temperatures up to 300 °C provide favorable conditions for development of medium- and high-enthalpy geothermal systems (Fig. 3).

Rezessy et al. (2005) inventoried the geothermal resources of Hungary, and calculated the total heat stored both in the rock matrix and in the water present in the geological formations of various ages to a depth of 5000 m. They demonstrated that the stored heat increases with depth from the Quarternary (Q) through the Upper Pannonian (Pa_2), Lower Pannonian (Pa_1), and Pre-Pannonian (Pre-Pa) sequences of the sedimentary basin. The amount of stored heat was found to be approximately 100,000 EJ (1 EJ = 10^{18} J). Most of the heat is stored in the rock matrix, with only 5% stored in the pore waters (Szanyi et al., 2009) (Table 1).

2. Geothermal facilities in the past, present and future plans

The first thermal well in Hungary was drilled into a shallow uplifted limestone reservoir in 1865, in Harkány. The first deep drilling was performed in 1868–1878, in Budapest, by a mining engineer, Vilmos Zsigmondy, who discovered 73.8 °C thermal water

* Corresponding author. Tel.: +36 62 544048; fax: +36 62 426479.
E-mail address: szanyi@iif.u-szeged.hu (J. Szanyi).

0375-6505/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.geothermics.2010.09.004

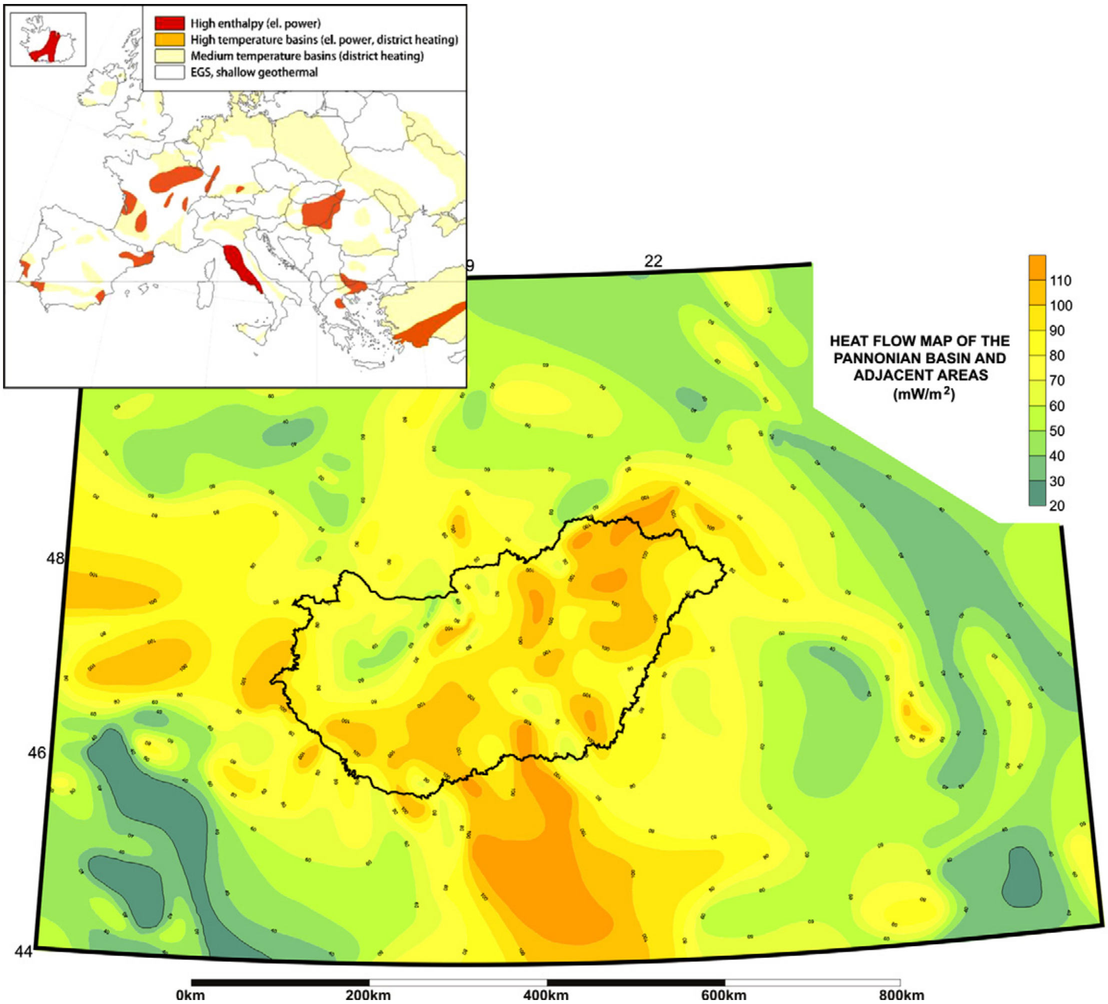

Fig. 1. Heat flow map of the Pannonian basin and adjacent areas, based on Dövényi et al. (2002). Inset (top left) is a geothermal thematic map of Europe, based on Antics and Sanner (2007).

with 1200 m^3/d yield at 970 m depth. After World War 1, several thermal reservoirs in Hajdúszoboszló, Berekfürdő, Szolnok, Szeged, Bükkszék, etc. were discovered by hydrocarbon exploration activities.

The balneological use of the Pannonian sandy thermal aquifers began in 1925, when a 1091-m deep well in Hajdúszoboszló yielded 70 °C thermal water. Later several drillings into this thermal aquifer were done in SE Hungary (Szeged, Karcag, etc.).

In 1958, the agricultural use of thermal water began in the Szentes area, where in addition to green-house heating, the water from 32 thermal wells is used for district heating. The Hódmezővásárhely Municipal Geothermal System, which is one of the most complex cascade use systems in the country, started operating in 1998. Several municipalities in SE Hungary (Szentes, Hódmezővásárhely, Kistelek, etc.) use thermal water directly for communal purposes and also for district heating. In addition, thermal-water-based spa and wellness use has been established in many other places (Mórahalom, Kistelek). Furthermore, several district heating systems using geothermal resources are currently in the planning and development phases.

To date, more than 1400 registered deep wells in Hungary have found thermal water, though only 950 are in production at present. Some of them are abandoned oil and gas wells, but they also include wells drilled for thermal water exploitation purposes. About 220 wells are used for balneology, and another 200 wells with water above 30 °C are used for public water supply. Approximately 200 such wells are used for agricultural purposes, of which half produce water over 70 °C. Unfortunately, only about 20 are injection wells, which shows that the direct use of water without injection is the current standard. Recent legislation prohibits new geothermal systems from being established without injection; only waters used for balneotherapy are allowed to be discharged at the surface.

For the shallower gravity-driven aquifer systems, the low pressure, and therefore, more sustainable injection into the porous sandy formations, started only about 10 years ago. Injection into

Table 1
Calculated heat potential in different geothermal formations; the rock formations are the same as in Fig. 2 legend (Rezessy et al., 2005).

Stored heat (EJ)	Q	Pa_2	Pa_1	Pre-Pa	−2500	−5000	Total
Rock body	140	4,030	6,318	16,741	12,053	57,765	90,047
Water body	35	636	351	893	568	2,652	5,135
Total volume	175	4,666	6,669	17,634	12,621	60,417	102,182