RATIONAL -ECOLOGICAL EXPLOITATION OF GEOTHERMAL WATER RESOURCE IN THE ROMANIAN WESTERN PLAIN

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Abstract

The Western Plain by its geological peculiarities is the warmest among similar formations in the country, offering the most favorable conditions of geothermal water formation. This explains the high frequency of exploitations by drilling and even of artesian springs used in the balneological and spa industry. The formation mechanism of these water deposits has its explanation in the high geothermal gradient (3-5°C / 100 m) due to the thin layers over the mantle and magmatic inclusions in depth, as well as to the permeability of layer.

Key words: geothermal water, ecological, exploitation, monitoring

INTRODUCTION

Conventional renewable energy (geothermal) present in the Western Plain (Crişuri Plain), is used mostly for spa and treatment therapy both in organized facilities and in guesthouses and in a small extent for domestic use. (see the annex Map of Romania's geothermal resources). However, due to the explosive development of such consumers, associated also to a long period of drought (about 9-12 years), the phreatic thermal flows dropped sharply, jeopardizing the operation of the above mentioned treatment facilities. The most eloquent proof is the decrease of the phreatic piezometric level that fed the sublacustrine natural spring of Ochiul Mare and Pompei, the drying of these ponds, located along the route of Peţa rivulet and other surface springs.

MATERIAL AND METHODS

Some advanced solutions (at that time), regarding the revitalization of the natural reserve Peţa in the book "Peţa and the thermal water lilly" (Şoldea V., 2001), are belated today, the feasible solution being the injection of water into the collecting area, simultaneously with the electronic monitoring of the exploited flow consumption. In the next part, I present with scientific arguments both the formation mechanism of thermal water, the sustainable and environmentally friendly mode of exploitation, and the monitoring of the entire system.

The geological configuration of the Western Plain: bordered in the East by Şomleu hills, in the South, South-East by Betfia and Haieu hills, and in the north by Cordău summits, piedmonts, extensions of Piatra Craiului

Mountains. The average altitudes of these foothills, hills and summits, are at greater heights than the plain (with 200 m), the showing geomorphologically a strong fragmentation until the low lying platform of Miersig plain with an altitude of about 140 m.

The geological structure (see figure no.1), is largely similar to the Pannonian one, the base being made up of crystalline schists over which sedimentary Tertiary and Quaternary layers are superimposed discordantly. The geological evolution of the secondary era, characterized by the sinking Hercinic base, facilitated the transgressive Triassic and Tertiary deposits (see Mutihac Geology of Romania, 1990).

The Triassic Period, consisting of transgressive deposits placed directly over the crystalline schists consisting of conglomerates, quartzite sandstones, loamy-sandy schists, dolomites and massive gray limestone (according to I. Berindei)

Jurassic Period consisting of transgressive deposits arranged over the Triassic ones, made up of red-violet clays-sandstones, gray quartzite sandstone, compact limestone marls with intercalations of clay-marly schists and limestone with echinoderms (according to Berindei I., Josan N., 1970).

Cretaceous Period, formed of transgressive deposits being dominant the gray and gray-black limestone and gray sandstones (according to Berindei I., Josan N., 1970).

The Tertiary Era is characterized mainly by vertical oscillations, followed by water flooding (emersions in Miocene-Neocene, flooding in the Pliocene), with depositions of lagoon - lacustrine type. The Pontian part of this era presents yellow sands at the surface and following the withdrawal of Pontic Lake, the species Melanopside disappear (Melanopsis pareyssi remaining as a relic) and the area of Nymphaea Lotus var termalis shrinks to the thermal lakes (according to Diaconeasa B, D. Popa, Olteanu I).

The Quaternary era is represented mainly by glacial deposits with considerable layers of peat, woody plant debris and sediment of tufa, rich in plant and invertebrate fossils (according to Berindei I., Josan N., Măhăra Gh., 1970).

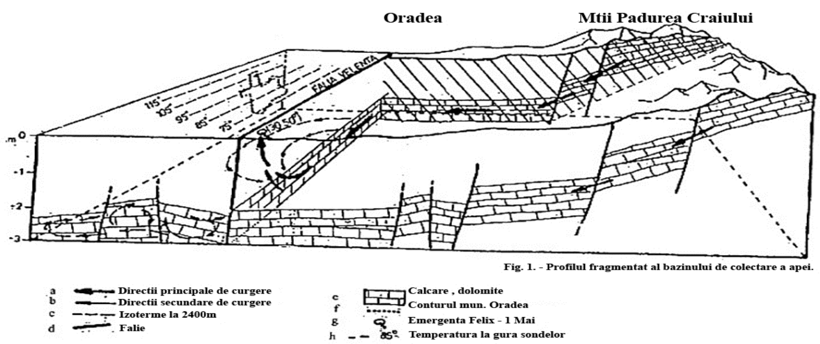

Fig. 1. Fragmented profile of water collection basin (according to Berindei et al., 1970)

RESULTS AND DISCUSSION

Most geothermal deposits are located in the western part of Romania, namely in the eastern part of the Pannonian Basin, a large Neogene mountain depression formed after the Carpathian region was affected by Miocene tectogenesis. The basin was formed by the stretching and thinning of lithosphere accompanied by continued sinking commenced in Badenian and continued with higher speed in Pannonian. During this period they have accumulated large amounts of sediments with a thickness of up to 4000 m in the western plains of Romania. Lithospheric thinning has led to significant thermal anomalies, natural geothermal flow with values of 85-100 W / m^2. The Pannonian Basin is the warmest region of Central and Eastern Europe. The geothermal deposits located in the permeable rocks of the Western Plain are the result of this high natural geothermal flux. They consist either of closed multi-layered regional aquifers, localized at the base of Pannonian Superior or from aquifers stretching relatively small, localized in the rocks of Pannonian Inferior or in the sedimentary cracked rocks of the sunk foundation (eg Mesozoic limestone and dolomite as in the deposits in Borş - Oradea - Băile Felix - 1 Mai area). The Pannonian geothermal aquifer is multilayered and closed on an area of approximately 2.500 km^2, along the western border of Romania (from Satu Mare in the north to the south of Timişoara and Jimbolia). The aquifer was investigated through 80 drills, which can be all used for production, but only 37 are currently exploited. In 2014-2015, other studies have been made requested by Ţării Crişurilor Museum and the Institute of Hydrogeology and the Faculty of Geology and Geophysics Bucharest.

From a geological point of view, the geothermal waters in the western part of the country are clustered in the following structures:

-porous-permeable-sandy rocks of Neozoic age, between 800 and 2100 m depth at the base of the upper Pannonian layers, characteristic of exploitations located in Satu Mare, Tasnad, Săcuieni, Marghita, Salonta, Ciumeghiu, Arad, Curtici-Macea- Dorobanţi, Timişoara, Tomnatic, Lovrin, Jimbolia, Sânnicolaul Mare areas;

- fractured carbonate rocks (limestone and dolomite) of Mesozoic age, at a depth of reservoirs located between 1000 and 3500 m, characteristic to exploitations of Oradea, Borş, Felix, Livada, Aleşd, Beiuş areas.

The geothermal water temperatures are between 40 and 120 ° C, the heat source is the upper part of the mantle (asthenosphere) and / or magma chambers located at various depths in the crust. The natural geothermal gradient is in this area of 45-55C / km. As a rule, the rate of the geothermal gradient is about 2.5÷3°C /100 m, which allows an assessment of the temperature around 65 ÷ 75 ° C at 2000 m depth and 90 ÷ 105 ° C to 3000 m (NAMR and the Institute of Geology and Geophysics Bucharest).

The hydro-geothermal deposits are generally divided into two categories:

- geothermal deposits with low enthalpy (Figure 4) with temperatures below 150°C commonly encountered at a depth of about 1000 m, typically located in sedimentary basins in areas with relatively small thickness of the crust, located near the edges of tectonic plates (for example, Paris Basin and Pannonian Basin and the great sedimentary basin in north-eastern and central of China). The low enthalpy deposits can be also found in the very old, inactive volcanic areas, having some deep magma or already cold intrusions as heat source;

- geothermal deposits with high enthalpy (Figure 2) with temperatures above 150°C at a depth of about one kilometer, located only in active volcanic regions, in the contact areas of the tectonic plates (faults and rifts). The heat source is the young magmatic intrusions at relatively small depths. Through heat enthalpy diagram, there is an exemplification of the dynamic mechanism of the heat transfer under pressure.

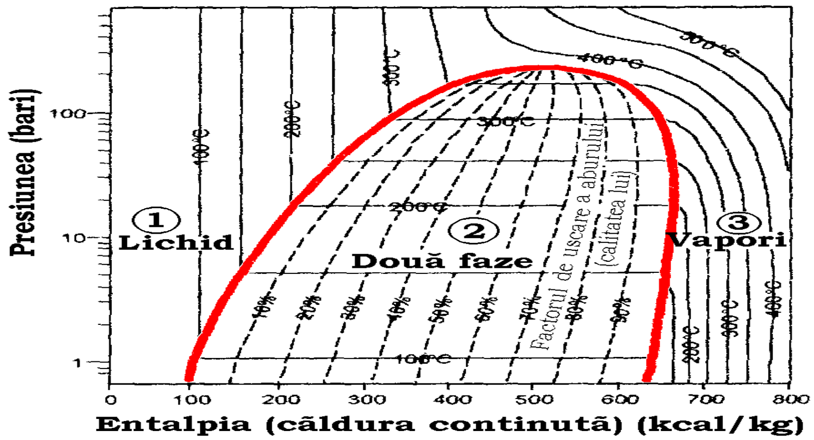

Fig. 2. Diagram of relationship pressure-enthalpy for pure water and steam with the thermodynamic conditions of the fluid in the reservoir.

1) Liquid water; 2) two-phase fluid: water and vapor 3) overheated vapor (according to Edwards et.al., 1982, as amended)

The bold line represents the saturation and vaporization curve for liquid water. If we consider a steam-water mixture on the saturation curve at a temperature of 250ºC and a pressure of 40 bar, the drilling in these thermodynamic conditions, may cause fluid in a variety of ways. For example, the output would consist of saturated liquid at an enthalpy of 260 kcal / kg (1.086 kJ / kg) or the saturated steam (dry) at an enthalpy of 670 kcal / kg (2.800 kJ / kg), or any mixture of steam and liquid water, with an enthalpy and quality ranging between that of dry steam and water. But usually, the geothermal steam, does not appear as pure water in the gas phase, but it contains gases such as CO_2, H_2 S, HF, NH_3, CH_4, H_2 in amounts ranging from deposit to deposit. In addition, in the particular case of a any reservoir, the gas content tends to decrease over time as a result of the production.

Theories and schemes on the formation of geothermal groundwater deposits: formation mechanisms of geothermal waters (the source consists in the infiltration of the rainwater in the deep Triassic layers. As they go into the depth, they take over the released warmth (geothermal gradient 3-5 * C / 100 m), and due to the diffuse flow (rate of renewal is about 30-50 years) they turn into geothermal steam or in vapors in some cases (v. Fig.1-8).

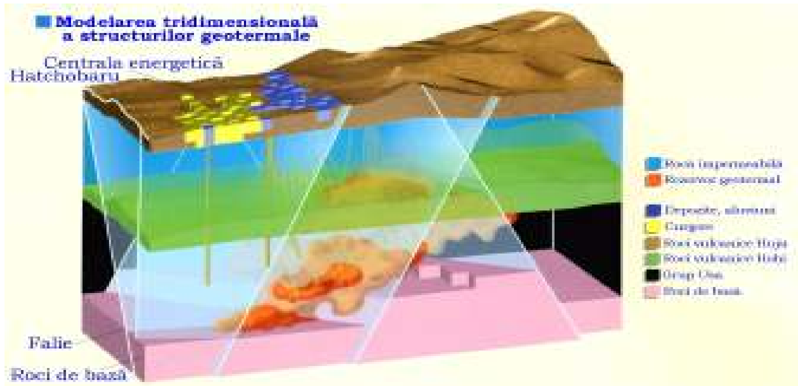

Fig. 3. Below present formation layout geothermal waters: 3-D model of an ideal geothermal system

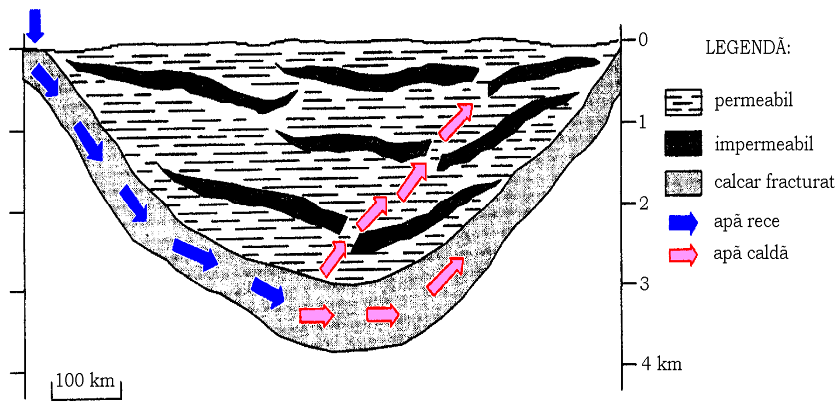

Fig. 4. Layout of low-enthalpy reservoir developed in a sedimentary basin (Ros, 1982)

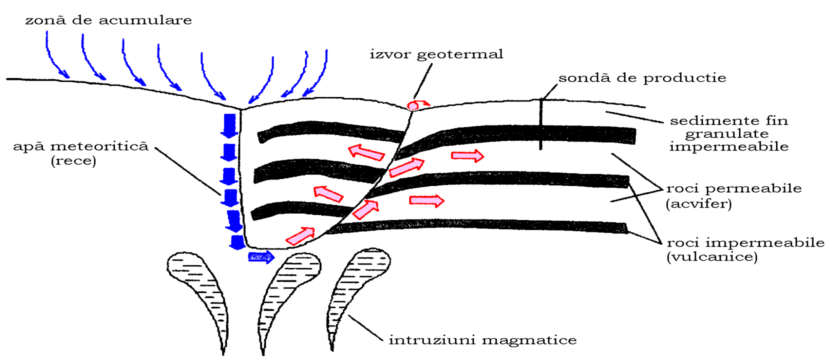

Fig. 5. Layout of high-enthalpy geothermal deposit (Ros.)

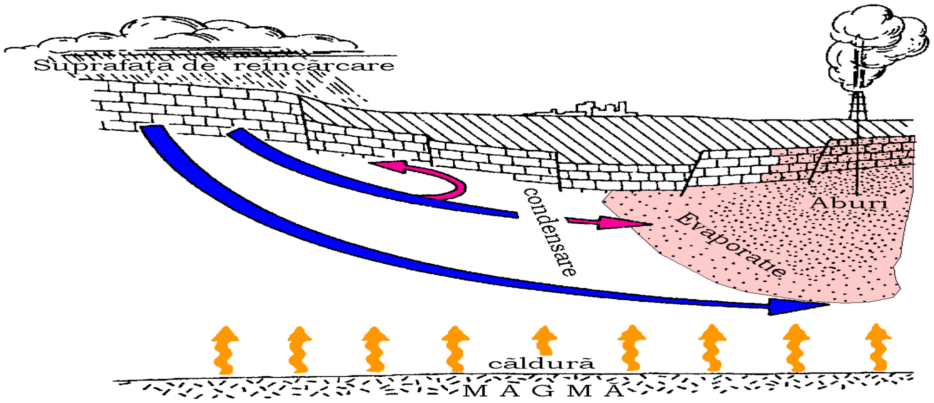

Fig. 6. The model of a deposit dominated by dry or overheated vapors. The vapors are the continuous and predominant phase in the reservoir. The pressure is approximately constant and present everywhere in the reservoir

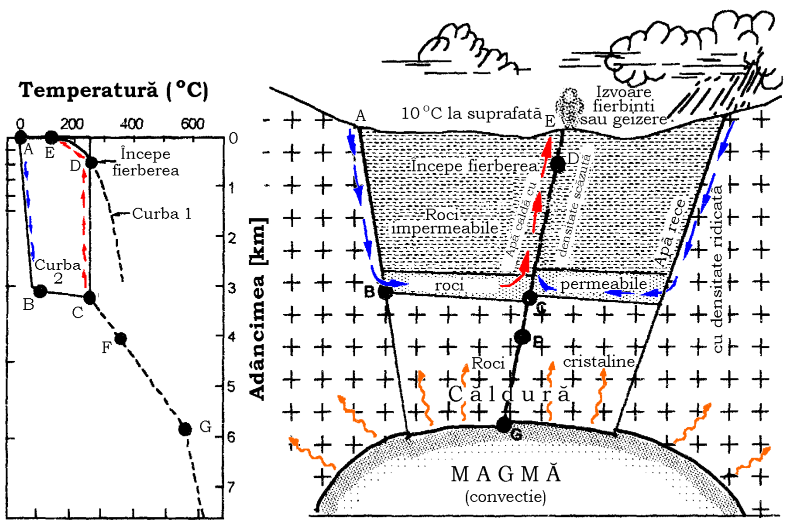

Fig. 7. The model of a wet steam deposit. Curve 1 is the reference curve for the boiling point of pure water. Curve 2 shows the geothermal gradient along a typical circulation route from point A from the reloading area to E, the unloading area

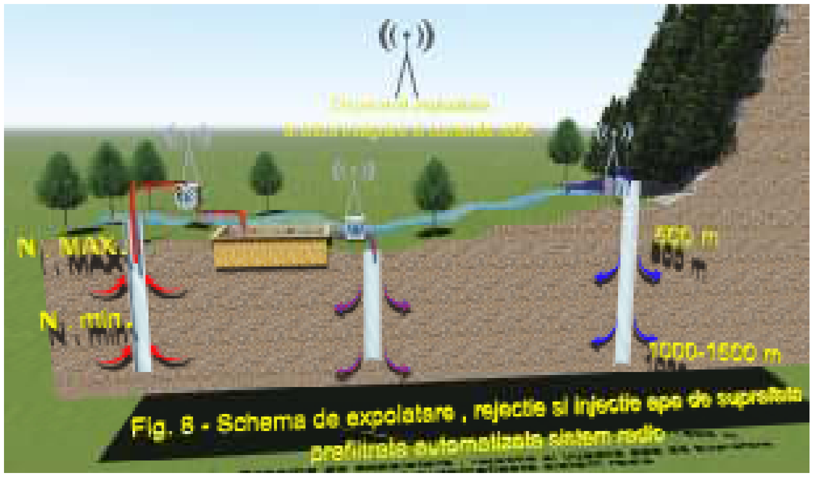

Fig. 8 - Schema de expolatare , rejectie si injectie apa de suprafata prefiltrata automatizata sistem radio

In Figure 8, I presented the control-monitoring scheme, of both the operating system, surface water injection that was previously filtered and of the re-injection one in the proximity of the exploitation or user drillings (according to Şoldea V., 2015).

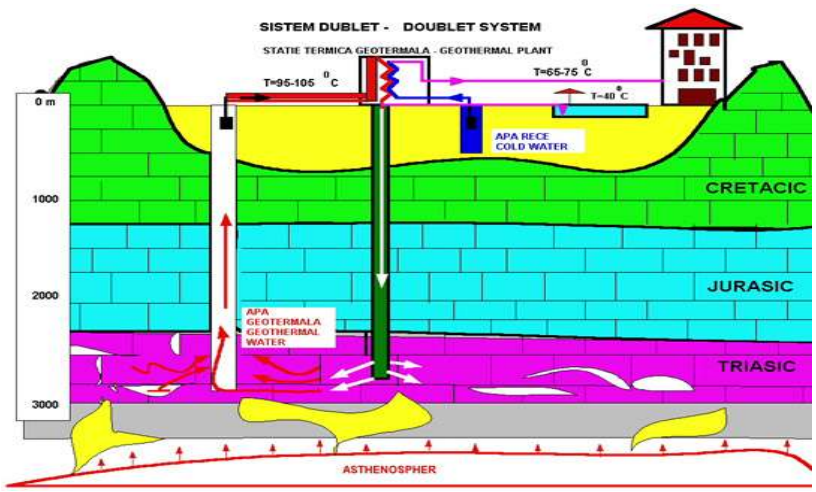

Fig. 9. Double system: capture-reinjection, consumer (SPA, geothermal heat station etc.)

The solution for the recovery of the piezometric level in the geothermal groundwater: the need to cover the increased consumption (flow of consumption of the spa industry) and to restore the piezometric level of geothermal groundwater lately, and because of the prolonged drought, it requires the solution of injecting the surface water, washed and filtered in advance, into the accumulation area.

At the base of this idea, the surface water injection is foreseen, to complement the lack of rainfall and the additional flow intake, to cover the increased consumption of the spa industry, but also to restore the piezometric level of the geothermal water.

For this purpose, the following equipment is foreseen:

- Electronic reception-transmission radio station to take over the radio signals (level, temperature, minimum and maximum) from the sensors of the exploitation drills, injection and reinjection to integrate them and deliver control signals (start-stop pumps)

-Antena or (satellite transponder) for transmitting and receiving radio commands to the effectors,

- Injection drills in the storage foothills area foreseen with settler, sand filter and injection pump Equipping the Western Plain in this manner may be functionally stable, ensuring constantly the flow rates necessary for the spa industry and related consumptions and can be monitored electronically, to balance the consumption with the intake of water in the reservoir.

CONCLUSIONS

1. The Western Plain by its geological peculiarities is the warmest among similar formations in the country, offering the most favorable conditions of geothermal water formation. This explains the high frequency of exploitations by drilling and even of artesian springs used in the balneological and spa industry.

2. The formation mechanism of these water deposits has its explanation in the high geothermal gradient (3-5°C / 100 m) due to the thin layers over the mantle and magmatic inclusions in depth, as well as to the permeability of layers (see figure 1-7).

3. Recently, the intensive exploitations by both the older established units and more recently in the private hotel units, associated with prolonged droughts (about10-13 years) without the reinjection at users, led to the sharp decline of the necessary consumption flow and a decrease of the piezometric level of the deposit, which requires the injection of surface clean water in the supply area to rebalance the flows of consumption and return the piezometric level to its initial value.

4. The injection of surface water, previously washed and filtered, in the area of accumulation by drills, represents the recovery solution of the deposits and a safe constant, designed to balance the consumption.

5. Radio-electronic monitoring of the exploitation drills simultaneously with the re-injection near the users as well as the injection of the water surface, creating the prerequisites of a stable equilibrium, not

allowing the misbalance of the exploitation flows and decrease of piezometric level of the thermal deposits.

6. Our Hungarian neighbors have also noted the decrease of consumer flows in the spa locations (Debrecen, Fuzoş Ghiarma; Hajdu), and they would probably be interested in a project with EU funds to constantly maintain the geothermal resources by monitorization-automatization.

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