The Hydrogeothermal System of Felix – 1 Mai Rural Spa

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The hydrogeothermal system Felix - 1 Mai, bedded in the Mesozoic carbonates of Bihor Autochthonous is a part of the northern hydrostructure of Piatra Craiului Mountains. At the moment, the thermal aquifer developed on lower Cretaceous limestones is under exploitation.

The first well was open for exploitation in 1885. At present there are 13 wells under exploitation. In this century a volume of one billion m3 water has been extracted through springs and wells, with around 200 million only from wells. This hydrogeothermal system is an "open" one. The debiting capacity requires a permanent supply.

The geotectonic evolution

The geotectonic evolution of the area is linked to that of the alpine-carpathian ensemble and that of the intracarpathian basin. This evolution comprises several Protero-Paleozoic cycles and the alpine cycle, developed in three main phases: geosyncline (Permian - Lower Cretaceous), orogene (Upper Cretaceous - Paleogene) and craton (Neogene). During the paleoalpine phase the area evolves within the Bihor - Codru geosyncline (Permian - Lower Cretaceous), during the mezoalpine phase within the marginal basins of Apuseni Muntains, and during the neoalpine phase the area is being sunk.

The geology of the system.

The metamorphic rocks forming the bedrock belong to the Protero - Paleozoic cycles. The alpine cycle formations belong to the Bihor Autochthonous. The mezo and neoalpine deposits are marginally situated and have reduced depths. The sedimentary cover is made up of:

- Pannonian deposits with a depth of 10 - 100 m;
- Upper Miocene deposits (Sarmatian - Badenian) with a depth of 0 - 60 m;
- Upper Cretaceous deposits (formations in Gossau facies) with a depth of 0 - 100 m and Lower Cretaceous deposits (limestone with pachyodontes) with a depth of 1200 - 1400 m;
- Medium and Upper Jurassic deposits with a depth of 400 m and Lower Jurassic deposits (Gresten formations) with a depths of 180 m;
- Upper Triassic deposits (Wetterstein limestone, Butan limestone, Pestiş schists, Vida limestone, superior dolomites, Bucea limestone) with a depth of 280 m and Lower Triasic deposits (inferior dolomites, Werfen schists) with a depth of over 1000 m.

The tectonics of the system

The present structure is a consequence of the sin and postparoxysmal movements of the alpine tectonics. This area is characterized by an advanced tectonization due to the crossing of several major accidents. The Felix - 1 Mai zone links the north - western Mesozoic deeply sunk with the eastern one of Şomleu Hill (+345 m); the compartments surrounding this outcrop of eocretaceous limestones being covered by thin tertiary sediments. The zone is limited by two faults oriented north - south (the 1 Mai fault in the east and the Valenţa fault in the west) and by two

faults oriented east - west (Copăcel – Vârciorog fault in the north). This small surface (20 km^2) is crossed by many faults separating compartments characterized by specific hydrogeological features.

The hydrogeology of the system

The hydrothermal acquifers are fissuration systems developed in carbonated rocks, with different degrees of fissuration, of Lower Cretaceous age, with a surface situated between 10 - 138 m in depth, in the active water area and are found at the surface in Şomleu Hill. The fissuration systems through which the geothermal water circulates are strongly developed in the upper part of the limestones. The very large dimensions of the fissures suggest their hydrothermal origin. The barrenian limestones include three fissuration systems with thermal waters.

Of the greatest importance is Complex I situated in the upper part of the Lower Cretaceous limestones, which are submersed and covered by Cretaceous marl - limestones and Pannonian clays. The fissuration system contains cavities and large underground channels with high flows. Most of the drillings intercepted a productive fissure at the limestone entrance. In the structural compartment 1 Mai, due to the elevated position of the collector system and to the intersection of major faults, powerful thermal springs were formed, at the points where the erosion removed the quaternary cover. At Băile Felix there was only one spring, with low flow, nowadays active, formed at the end of one fault. This acquifer constitutes a hydrothermal ring of these springs. This ring was structurally conditioned by the earthquake that took place at the 15th October 1834. The flow under exploitation doesn't depend on the depth of the open gap. Through the interception of a single fissure the whole flow offered by that difference in level can be drained. After some wells were closed, the flow of the natural springs increased, and after their opening it decreased.

The Complex II, formed as a network of finer fissures in limestone intercepted through deep drillings, is less known. The Complex III, with a low thermally, formed in a very weak fissuration system, has a theoretical importance because it is utilized.

The geothermal characteristics of the hydrogeothermal system

The positive geothermal anomaly (80 - 130 mw/ m^3) noticed in the Pannonic Depression (P. Dövény et al., 1983) is isolated from the adjacent structures, for which reason it has been linked with the formation of the basin. The geothermal maximum is well represented at the base of the lithosphere, too. Temperatures of 1000 - 1200°C at 60 km indicate the possibility of the partial melting of the lithosphere (F. Horvath, L. Stegena, 1976). The geothermal anomaly may be explained through the lithosphere extension model. In the conditions of a continuous horizontal extension, at a constant speed, a relatively uniform depth and a strong thermic flux of the whole basin are reached. The thickening is compensated at the surface by subsidence and sedimentation, and at the base by the addition of melted basaltic material, phenomenon known as "diapirism of the mantle" (S. Veliciu, 1984). In the Pannonic Depression the subsidence process started in badenian, continued in Pannonian (rapid subsidence) and is maintained in the present. The geothermal regime is dictated by the raised thermic flow, typical of the whole Pannonic Depression. The temperature distribution of the Cretaceous collector illustrates the western feeding of acquiferous complexes and the structural conditioning on the acquiferous through the upward circulation along the faults. The pronounced convection, elevating along N - S and E - V oriented faults is marked by the positive geothermal anomaly of 15 - 30° C at a 40 m depth. The geothermal maximum of the anomaly is on the route of Valenţa fault (13 - 14° C).

System capitalization

The area research through drillings started in 1885 when the Balint drilling intercepted a fissure at a depth of 47.2 m, from where water of 49°C and 196 l/s artesian water was yielded. The other drillings yield different flows: Izbuc well at 1 Mai (1886 - 1887) 25 l/s with 42°C; 4,011 Felix drilling (1962), with 46-105 l/s and 49°C, at a depth of 147-151 m in Complex I; 4012 well (1963), in Complex II, at 400-600 m, 25 l/s and 39°C; 413 well 1 Mai (1964) in Complex II with 25 l/s and 33°C; 4,003 Felix, at a depth of 59 m, with 121 l/s and 45°C; 402 Cordău well (1971) at 176 m, in Complex I with 8 l/s and 37°C; 4,087 drilling (1973) at 200 depth, in Complex I, 45 l/s and 42°C; F2 drilling (1975), in Complex I at 145-170 m, 200 l/s and 42°C; Izbuc Nou (1986) with 80 l/s and 40°C.

The characteristic parameters of the exploitation (flow, temperature, and pressure), due to the extraction intensification, recorded a production decline, superposed over a slow geologic decline. The thermal springs constitute the natural discharge zone

of the geothermal system developed in the Mesozoic carbonates of the Borod - Oradea Depression. The functioning of the natural emergencies is proved to exist since the first glacial phases through the fossil points with hydrothermal rings and thermophilic fauna at Şomleu Hill. The ceaselessly functioning of the springs maintained the thermal lake ecosystem in which the sapropelic mud deposit was formed and where tertiary relicts of flora (Nymphaea lotus var. termalis) and fauna (the Melanopsis parreisi gasteropod) were preserved and declared natural monuments.

The maximum requirement of thermal water in Felix and 1 Mai resorts

Felix base for treatment, with a capacity of 6,700 beds (19 hotels) and a permanent season, has a maximum consumption of 9,140 m^3/day, and the swimming pools, with a capacity of 17,000 places, out of which 12,000 places held by Felix between May - September, requires in the summer 5,400 m^3/day. 1 Mai base for treatment, with a capacity of 1,110 beds (4 hotels), have a maximum consumption of 1,240 m^3/day, and the swimming pools, with a capacity of 12,600 places, and a May - September high season, requires 2,100 m^3/day. 1 Mai camping site, with a capacity of 1,551 places, requires 3,250 m^3/day.

The physical and chemical properties of the geothermal fluid

The Felix - 1 Mai acquifer has a hydrodynamic link with the Oradea acquifer. After 1982, when the cumulative extracted was exceeding or was going towards the supply flow, the potential flow decreased. Through the intensive exploitation of Oradea acquifer, the Felix - 1 Mai acquifer might "run dry". In 1983 the thermal lake Ochiul Mare has frozen for the first time because the sublacustrine spring ran dry. The total flow of Peta brook, which collects the water of the thermal springs, declined from 143 l/s in 1977 to 50-60 l/s in 1986, due to the exploitation intensification of the Oradea area. The thermic regime of the thermal sources maintains itself constant around certain average values, the oscillations showing greater amplitudes after the exploitation of F2 well, when a maximum debiting capacity of Complex I was reached.

The geothermal fluid is a complex solution of dissolved salts and gases, subsatured in the conditions of a deposit. The chemical analyses performed between 1976-1986 indicate the stability of the chemical composition. The waters show a low mineralization, with values of 500 – 1,300 mg/l and are of a bicarbonate – sulfate – chalco – magnesian origin. The low mineralization certifies the relatively short time of residence of the water in the acquifer. Dissolved gasses are in a reduced quantity, with a solution rate of 0.027 – 0.056 Nm^3/m^3. The geothermal fluid contains radioactive elements. CMA has a value of 0.7 – 3.2 pCi/l at 1 Mai and 0.8 – 3.3 pCi/l at Felix. Rn – 222 concentrations are similar to those of surface waters, $0.6 - 2.1 \cdot 10^{-10}$ pCi/l. The chemical composition and the radioactive isotope concentration are proofs of the vadose origine of the acquiferous waters. They are located within the domain of waters belonging to active hydrologic cycle due to its relatively young age (cca 23,000 years).

In the conditions of relatively constant thermic flux, on a surface extending over 12 km in length (Oradea – Felix), at the level of the collector a progressive temperature decline is recorded from the west (110°C) to the east (77°C) on alignments parallel with the Valenţa fault. The cooling of the eastern zone suggest the existence of an increased convection along the fault and proves the rapid dynamics of the hydrogeothermal system, the hydraulic conductibility of the fault and certifies the open character of the convective type – system, with an active dynamics. The water running in the system is oriented towards the point of natural discharge through springs.

Conclusions

In the conditions of the extraction of 180 l/s flow, with only half of it being used for treatment and a third as domestic water, it is estimated that measures for securing a rational exploitation should be imposed, in order to preserve and protect the deposit.

References

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