GEOLOGICAL AND HYDROGEOLOGICAL CONSIDERATIONS REGARDING THE POSSIBILITY OF USING GEOTHERMAL ENERGY IN THE AREA OF SÂNGEORZ-BĂI

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Abstract. This study inventories the existing data regarding the hydrogeology of the northern region of the Bistrița-Năsăud County and for the area of the city of Sîngeorz – Băi; we made a field research, too. Among the existing data, in addition to geological maps, previous measurements made under the IGR (petrography, hydrogeology, gravimetry, magnetometry and geothermal) were used. We can consider the zonal geothermal potential as favourable, but in order to put it into operation, studies that are more detailed and data from at least one deep drilling are necessary. From the point of view of energy efficiency and without taking into account the financial scale required by a deep drilling, on a local scale, heat pumps can be used.

Keywords: geotermal, hidrogeologic, Sîngeorz – Băi.

Rezumat. Consideraţii geologice şi hidrogeologice cu privire la posibilitatea utilizării energiei geotermale în arealul orașului Sîngeorz-Băi. Prezentul studiu inventariază datele existente referitoare la hidrogeologia regiunii de nord a județului Bistrița-Năsăud și pentru zona orașului Sîngeorz – Băi, s-a făcut de asemenea și o recunoaștere în teren. Dintre datele existente au fost utilizate, pe lângă hărțile geologice, și măsurători anterioare realizate în cadrul IGR (petrografie, hidrogeologie, gravimetrie, magnetometrie și geotermie). Putem considera potențialul geotermic zonal ca favorabil, dar pentru punerea în exploatarea a acestuia sunt necesare studii de detaliu și date din cel puțin un foraj local de mare adâncime. Din punct de vedere al eficientizării energetice și fără a lua în calcul amploarea financiară presupusă de un foraj de mare adâncime, la scară locală, pot fi utilizate pompele de căldură.

Cuvinte cheie: geotermal, hidrogeologic, Sîngeorz – Băi.

INTRODUCTION

The perimeter of Sîngeorz-Băi lies on the boundary between the sedimentary cover of the Transylvanian Basin and the crystalline zone of the Rodna horst (see Fig. 1). In order to summarize the geology of the area, we will use the more didactic division of the area, according to the main formation processes, into three domains: metamorphic, sedimentary and magmatic (next chapter - Geological and tectonic characterization).

A brief field check has been made of the data contained in previous works. Of the existing data, in addition to the two geological maps (PATRULIUS et al., 1968; KRAUTNER et al. 1989), the present study uses the data and analyses of two reports prepared in 1982 and 1989 within the IGR by Veliciu S.

GEOLOGICAL AND TECTONIC CHARACTERISATION

Metamorphic domain. The crystalline bedrock occupies the northern part of the studied perimeter and outcrops together with elements of the Rodna subbucovinic rocks. Thus, north of the confluence of the Cormaia and Magura valleys, the Rodna Belt outcrops (Rebra series with the Ineu formation - mica schists, quartzites and the Voșlăbeni formation - mica schists, paraamphibolites, marble limestones, dolomites).

The crystalline bedrock (Upper Ante-Proterozoic, Upper Proterozoic-Lower Palaeozoic, Palaeozoic) consists of a succession of epi- and mesometamorphic rocks which are arranged from the base to the surface as follows: the Bretila Formation: lithologically it is characterized by amphibolites, gneisses, ocular gneisses, granulites and basic and ultrabasic metaeruptive intrusions. The age is Middle Proterozoic (1660 mil. years); the epimetamorphic Tulgheș series: it is divided into 4 lithological formations, consisting of muscovite quartzites, sericite-chlorite schists in the base, over which graphitic rocks are laid out; the Repedea series: green - sericite-quartzite schists sometimes laminated, the presence of chloritoid is also reported; the Lespedea formation: gneisses, amphibolites.

Sedimentary domain. Along the valleys there are specific terrace deposits of Quaternary age with sands and gravels. The sedimentary domain is predominantly present in the southern part (see Fig. 1) where a succession of sedimentary deposits is found, based on the Paleogene with quartz conglomerates and sandstones, quartz and calcareous sandstones, clayey and greyish marls and the lower part of the Miocene represented by marly greyish mudstone formations.

Above the Paleogene-age formations, there is a post-tectogenetic blanket of non-genetic formations represented by calcareous sandstones, marls and marly clays.

The Eocene formations are very restricted in the area of the Sîngeorz-Băi, a small patch being part of the mamelon at the confluence of the Tatălui valley with the Borcutului valley, calcareous tuff of 1.5 - 15.5 m thicknes formed the mamelon. The Eocene complex up to a depth of 55 m is composed of greyish-black, sometimes sandy marls with thin intercalations of grey marls or very hard grey limestones crossed by calcite-filled diaclastics. At a depth of 55 m, the two boreholes drilled by IGEX (1963) and ISPIF (1968) in the Borcut valley entered a complex of fine to coarse, greyish sandstones, sometimes with limestone-filled diaclastics to a depth of 150 m, from which depth a rhyodacitic body was intercepted. The marls and sandstones encountered in the boreholes, known as the "Moara lui Sandu strata", are considered to be of Upper Eocene or

Priabonian age. Eocene (Lutetian-Priabonian) numulitic limestones outcrop over small areas south of Sîngeorz-Băi and canton aquifers discharging through springs with low flows and low concentration (0.02 -0.05 l/s) (VELICIU et al., 1989).

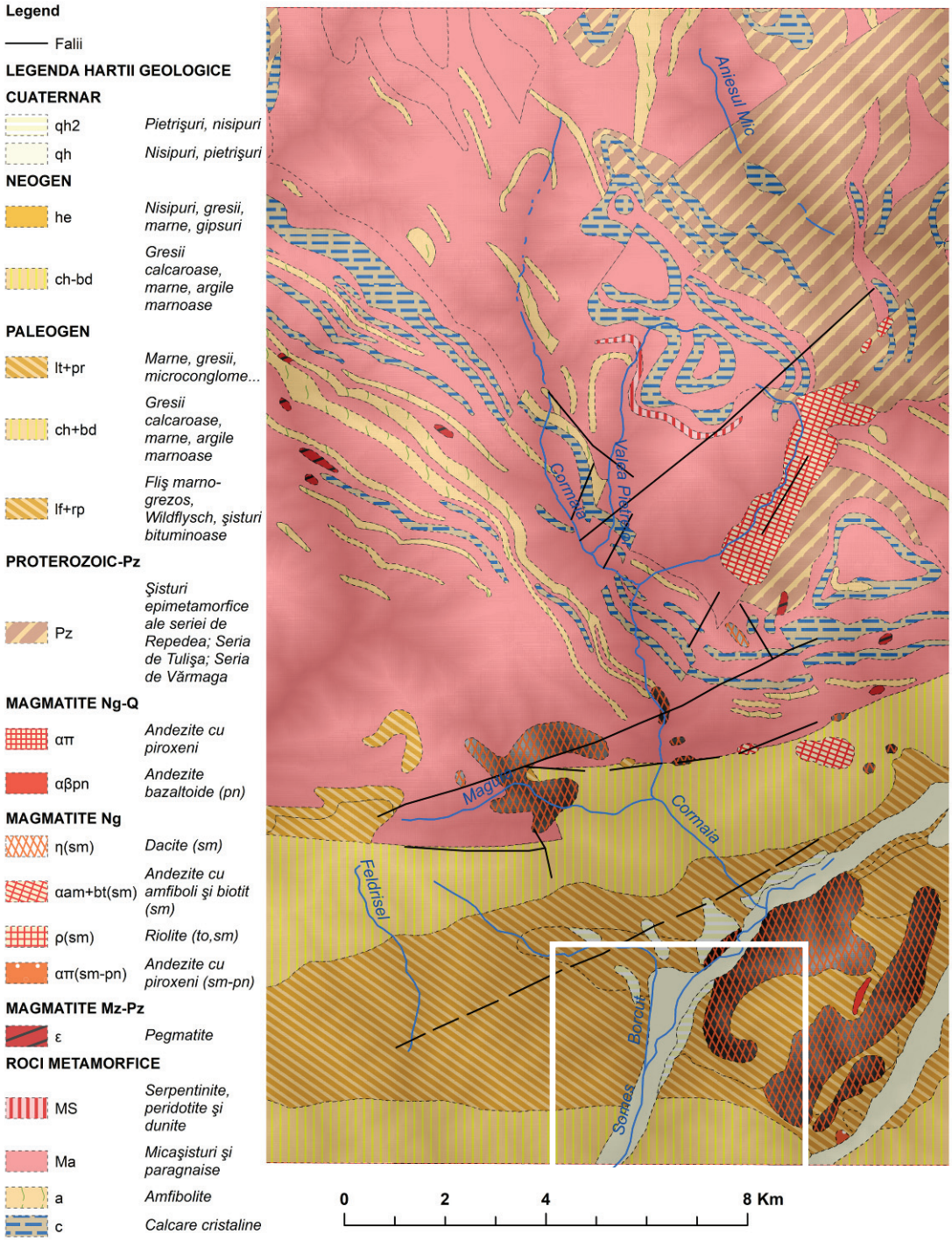

Figure 1. Geological map of the region, location of the study area is marked by the white box (after PATRULIUS et al., 1968 and CONSTANTINA et al., 2021).

Magmatic field. In the Neogene (11.4 and 8.0 Ma - K-Ar dating, PÉCSKAY et al., 2009) sedimentary formations of Eocene, Oligocene and Quaternary age were pierced by magmatic bodies of acidic and intermediate composition (rhyodacite, dacite, andesitic quartzite) belonging to the western alignment of the Eastern Carpathian subvolcanic zone. The intrusions were mainly in the form of dikes.

The contact zones between magmatic rocks and sedimentary rocks are often marked by hornfels and, less frequently, breccias (PÉCSKAY et al., 2009).

Eruptive formations were encountered in the borehole drilled by IGEX at a depth of 159.8 m to the final borehole depth of 297.2 m. These formations are represented by biotite rhyodacite. On the Cormaia Valley, next to the

dacite quarry - Izvorul Crețului outcrops a body of dacite with biotite in contact with the retromorphosed gneisses of the Rebra Group. The contact is sharp and the host gneisses are very weakly affected by contact metamorphism. They are micaceous gneisses with garnets, which in the contact zone show cataclasis, materialized by small feldspar and quartz porphyroclasts, fish-shaped micas and a milonitic foliation (overlying the relict), which moulds these porphyroclasts (MOSONYI & URECHE, 1998).

Tectonics. The Someș Mare Fault, highlighted since 1982 (Visarion in VELICIU et al., 1982), is an important transcrustal fault separating two major structural units (the Rodna Mountains and the sedimentary deposits). A system of parallel faults is associated with it, as well as some minor, perpendicular faults that support its decropping character.

In order to illustrate the issues related to the theme of the geothermal tectonic potential of the region, which imprints its characteristics on the perimeter of Sîngeorz - Băi, two geological sections were studied: the first between Parva and Valea Țibău - (IGR geological map, scale 1:200. 000, PATRULIUS et al. 1968) and the second one oriented in the south-western part of Sîngeorz-Băi (IGR geological map, scale 1:50.000, KRAUTNER et al. 1989).

The first section, located in the neighbouring territory, captures very well the structure of the sedimentary deposits at the contact with the Rodna Mountains and highlights the fault separating these two major structural units, the Someș Mare fault highlighted since 1982 (Săndulescu &Visarion, 1978 apud VELICIU et al., 1982), an important transcrustal fault. A system of parallel faults is associated with it, as well as some minor, perpendicular faults that support its decropping character. The broad anticlinal ridges to the S of Someș have approximately N-S directions and slightly inclined flanks and are formed in the area of the salt masses above the Dej tuff. The tectonic features in this area are of minor importance (they produce local bumps) and represent effects of salt tectonics. The sedimentary blanket, which replenishes over the felsic formations, is about 2500 m thick.

The second section represents two synclines, one on the Cormaia valley and the other on the Ilvei valley, which are margins of the depression basin. According to this section, the thickness of these sedimentary structures, which rebound over the crystalline bedrock, is 1200 m.

An important issue in estimating geothermal potential is whether there are magmatic sources in the region that generate thermal anomalies. From geophysical data (VELICIU et al., 1982):

The central-western area of the Rodna Mountains is dominated by a regional magnetic anomaly, with the apex located between Vf. Craiului, Vf. Muncelului and Vf. Cornul Arșiței. Based on this anomaly, a deep magmatic glass is assumed, from which a series of subordinate bodies and apophyses are derived. This interpretation is also supported by some detailed magnetic surveys carried out in sector V. Tatarului - V. Orgii, on the south-western flank of the positive term of the anomaly (Pitulea, 1979 in VELICIU et al., 1982), which in its vicinity show the existence of subvolcanic bodies at the surface (east of the Molidis springs), through local anomalies.

The southeastern part of the studied region is marked by the existence of several magnetic anomalies, which differ in intensity, morphology and extension on the surface, mainly reflecting subvolcanic masses of the Rodna - Bârgău group. It should be noted that unlike the SE sector, where the subsequent neogene magmatism develops in extrusive facies, the territory corresponding to the mountain area corresponds to a zone of predominant manifestation of intrusive subfacies magmatism (Veliciu et al., 1981 apud VELICIU et al., 1982).

RESULTS

Geothermal characterisation. In this study, we will analyse the geothermal potential of the region in terms of both conductive and convective geothermal systems.

În the region predominantly conductive geothermal systems, which generate a high geothermal flux (>70 mWm^{-2}) due to heat conduction in the rocks (hot dry rock areas) develop higher regional temperatures.

In the researched region there are convective geothermal systems too, which are formed where the heat content is due to the circulation and accumulation of waters having a certain degree of thermalization. The circulation is carried out on the fractures, and the accumulation is related to the aquifers constituted in rocks that are characterized, as a rule, by a secondary permeability (cracked crystalline rocks, or karstified carbonate rocks), or by a primary permeability (mainly belonging to flysch formations from the post-tectonic cover).

Before 1982, in Bistrița - Năsăud county, the only observation data on underground temperature came from measurements made on gas-bearing structures, or in the two deep boreholes drilled by IFLGS (4141 - Beudiu and 4135 Bistrița).

In 1982 and 1989 Veliciu elaborated two complex geothermal studies for the Țibleș - Rodna region. In order to produce maps illustrating the location of potential geothermal resources in the Tibleș - Rodna Mountains region, Veliciu analysed the cumulative effect of several types of factors, including: heat flux values and rock temperatures; surface geothermal manifestations (mineralized springs with temperatures significantly exceeding the annual average water surface temperature); geochemical thermometry; areas with mineralized springs and CO_2 emanations; 7 million year old magmatic manifestations; permeable rocks - potential collectors; faults - geologically mapped or geophysically inferred; alignments in magnetic field distribution; regional gravimetric maxima.

The following data were used for the maps (Figs. 2-3): six deep, mineral exploration boreholes, where heat flow values were obtained from thermal gradient and thermal conductivity measurements; use of pre-existing data from 44 hydrocarbon wells from 2 hydrocarbon structures (bottomhole temperatures, productive stratum temperatures,

thermal logs), for which temperature-depth plots were developed; measurements in 40 short geothermal prospecting boreholes (50 m depth) oriented N-S, perpendicularly on the major geological structures in the region and two other boreholes located in the Dragoş stream valley; study of the temperature, chemistry and geographical distribution of natural mineralized emergences; the study of the silica content of mineralized outcrops whose solubility is dependent on temperature at depth.

These data led to the following conclusions: *temperatures in the range 60°C - 80°C at depths of about 2000 m were recorded in the 17 hydrocarbon structures in the Bistriţa Năsăud county; representation of these temperature values led to the delineation of thermal anomalies, one of which is located (near) at Sîngeorz - Băi; some of the temperatures obtained by direct measurements at the springs significantly exceed the average air temperature at the ground surface (8-10°C) and are suspected of a thermic water input from depth; thus, the geographical distribution of springs with temperatures of 12°C and above indicates a concentration of springs in certain areas and preferential directions; among other areas, there are also emergences (springs and boreholes) with temperatures between 10 and 15°C in the Sîngeorz - Băi area, on the fault that limits the Rodna crystalline massif to the south; based on the silica content of mineralized outcrops resulted that the temperatures of the emergences can be considered as the minimum temperature of the convective system, while the equilibrium temperature of the silica is a suggestion of the temperature of the water at depth. For Sîngeorz - Băi the application of this method resulted in estimated depth temperatures above 70°C.*

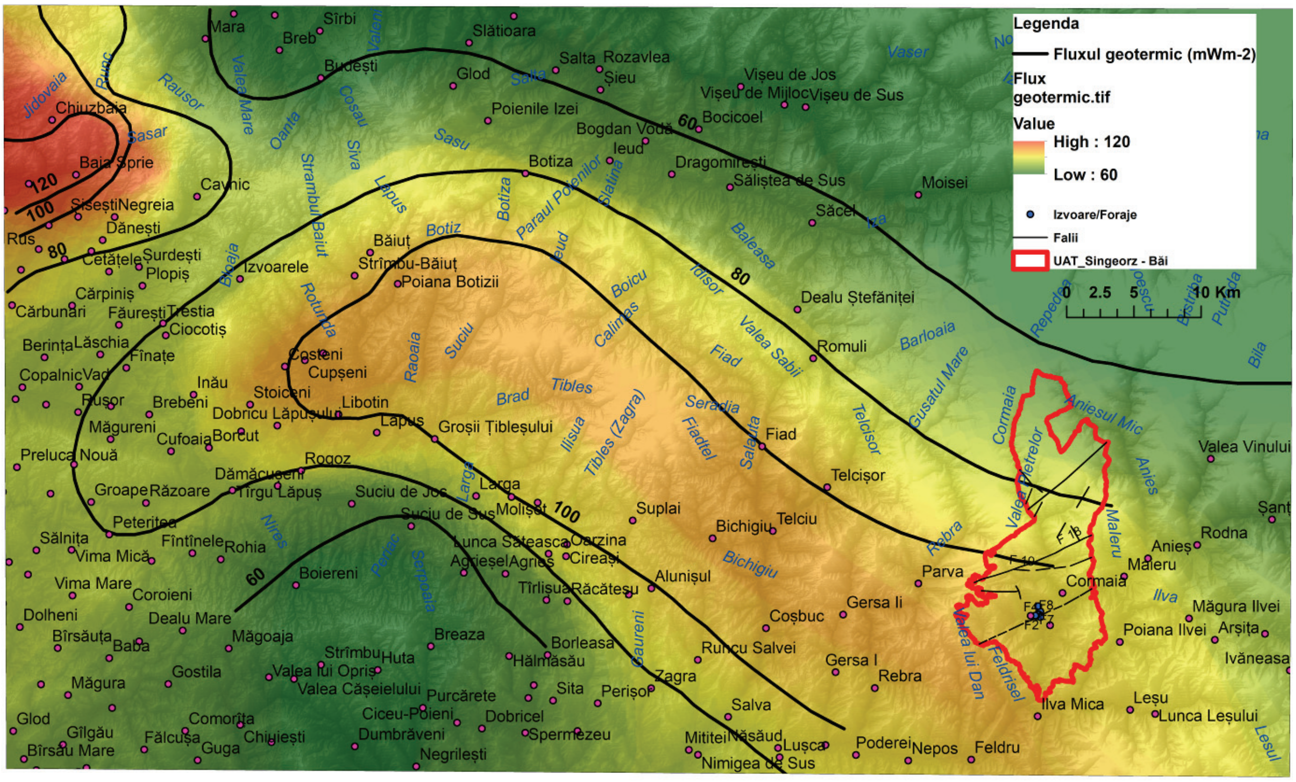

Figure 2. Geothermal flow map in the Rodna area (after VELICIU, 1982 and CONSTANTINA et al. 2021).

The cumulative effect of the data influencing the geothermal potential was translated by VELICIU et al. (1982) into numerical values for geophysical data using a 20 x 20 km quadratic grid and for geological data using a 10 x 10 km grid, and the geothermal flux isolines resulted. Also, taking into account the above-mentioned factors and based on the existing data, he produced temperature at 2000 m depth isolines. The existing data did not allow the contouring of the isolines to the east, however, in order to exploit them and draw some conclusions for Sângeorz - Băi, we interpolated both the geothermal flow isolines and the temperature isolines at a depth of 2000 m, obtaining 2 spatial distribution maps of these parameters, namely: geothermal flow map (Fig. 2), rock temperature map at 2000 m depth (Fig. 3). Spatial analyst from ArcMap 10 was used for kriging interpolation. Although only informative, the values resulting from this interpolation, in conjunction with the data collected from the field in the 2021 campaign, allowed the conclusions presented in this article to be drawn.

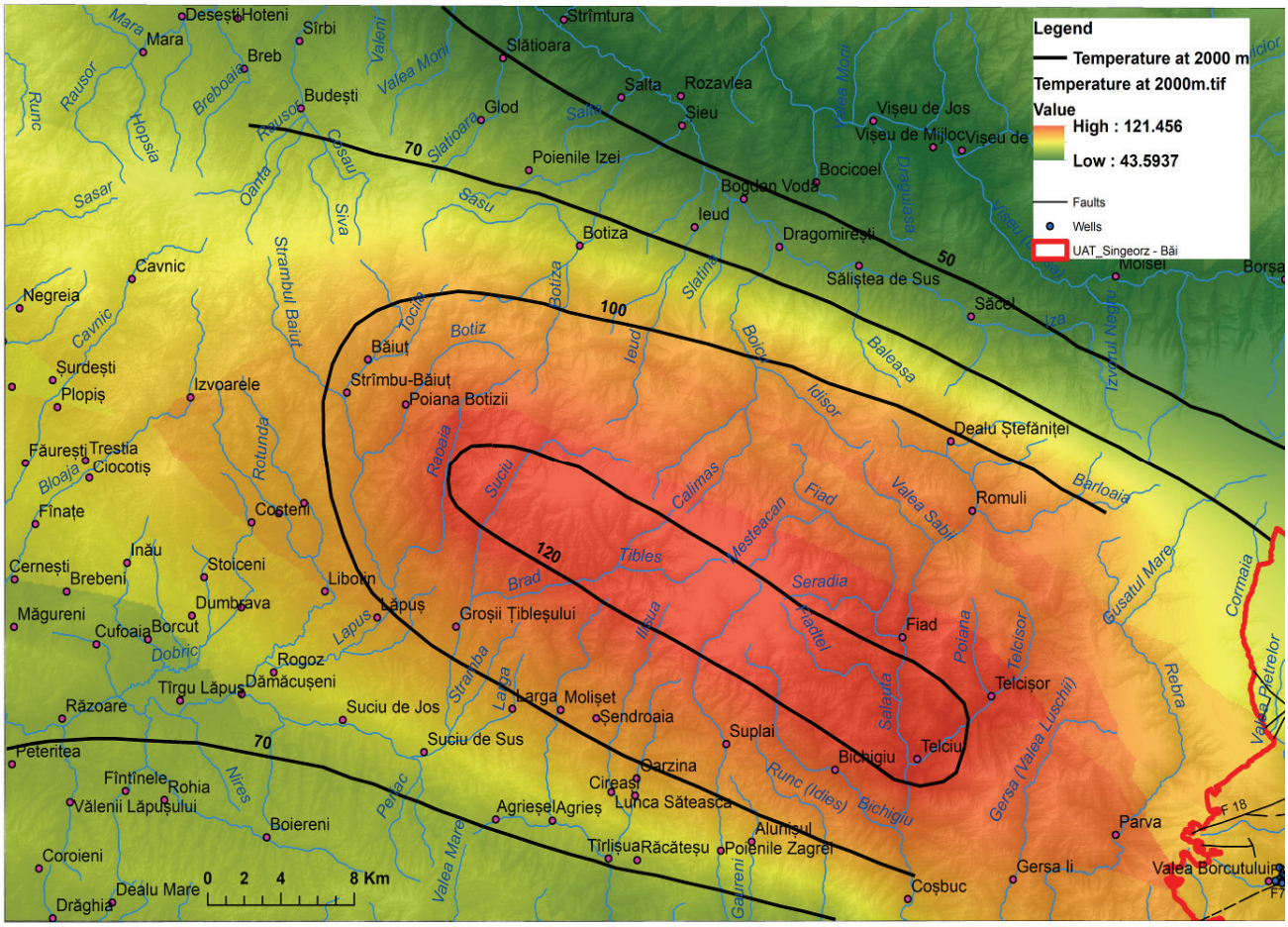

Figure 3. Temperature map at 2000 m (after VELICIU, 1982 and CONSTANTINA et al., 2021).

As shown in figure 2, the geothermal flow in the region is quite high, reaching values of 100 mWm-2 in some areas. As for the rock temperature map at 2000 m the existing data did not allow an extrapolation of the values for the whole area of the ATU Sîngeorz - Băi, but for the west of the locality values of about 80 - 100°C were estimated (Fig. 3). On the basis of these data contained in the 1982 report, its coordinator, S. Veliciu, recommended, and we quote: "the Sîngeorz area, although without remarkable geothermal activity, is interesting to explore by drilling about 1000 m deep, for a possible balneological use of waters with reduced thermalization".

Also, in his 1989 report, focused on the territory of the Bistrița - Năsăud county, S. Veliciu concludes: it is estimated that the average thermal gradient is 20 - 25°C per kilometre, and the temperature at depth reaches values of 60 - 70°C at 3000 m for the Bistrița area, a fact confirmed by the measurements made in boreholes Bistrița 4135 and Beudiu 4141.

This chapter has referred to the potential of the existence of conductive systems in the region. However, in addition to the existence of positive rock temperature anomalies, the existence of heat-transmitting fluids and the possibility of accumulation and flow of these fluids must also be considered. Therefore, the possibility of convective systems will be analysed in the next chapter.

Hydrogeological characterization. Previous hydrogeological mapping carried out in the geothermally surveyed area by various IPGG prospecting teams (Panaitescu et al. (1986, 1989), Lupu (1974), Rusu (1970, 1971), Geamănu (1971) apud VELICIU, 1989) has led to the separation of high, low permeability or impermeable formations.

The permeable deposits, belonging to the Transcarpathian flysch, which could host geothermal aquifers are, in a sequence starting from the surface in depth as follows:

- High-permeability formations consist of unconsolidated quaternary deposits (but of no importance for possible thermalised aquifers) or strongly fissured and tectonised magmatic or crystalline rocks with secondary permeability.
- Included in the category of low permeability formations are deposits in which water movement is through pores and interstices (fine sands, sandy-clay alternations, and sandy-marl), or through fissure zones (sandstones, numulitic limestones, microconglomerates, conglomerates, tuffs).
- Eocene (Lutetian - Priabonian) numulitic limestones outcrop over small areas in the studied region (south of Sîngeorz - Băi, north of Lunca Ilvei) and host aquifers discharging through springs with low flow rates and low mineral concentration (0.02 - 0.05 l/s and 0.4 l/s respectively). A series of emergences occurs at the contact with the Borșa sandstone.

- Oligocene and Miocene sandstones host aquifers mainly in the tectonization zones on the left bank of the Someș river.
- The Helvetian sedimentary formations contain small aquifers in the microconglomerate and conglomerate fine sand strata with low flow rates.
- The Lower Badenian, represented by an alternation of conglomerates, tuffs, sandstones, sandy clays, presents conditions for groundwater accumulation.
- The Volcanic-Bayesian and Pannonian formations, with low permeability of interstitial type, comprise mainly alternations of sandy clays, sandy marls and fine sands. The aquifers of these formations discharge through springs with flow rates of 0.001 - 0.04 l/s and very low concentration.

The impermeable formations are generally represented by the Oligocene marly shales (Latorfian - Rupelian) and the salt formation (Middle Badenian) having a predominantly pelitic character, which are practically devoid of water accumulation. Depending on their surface and depth distribution, these types of deposits can form the bed or roof of aquifers.

Although low, there is an upward circulation of water from the formations underlying the Middle Badenian age deposits (salt formation), which occurs through fissuring and dissolution voids in the salt. This is important because it produces water mineralization as salt springs with very high total mineralization values (50 - 150 g/l).

There are two deep wells in the region that may give indications of deposits that a potential geothermal well may intercept. Thus, at the **F 4135 Bistrița** borehole, layer tests were performed at the following intervals of hydrogeological interest:

- the interval 2308 – 2295 m – Helvetian – discharged 70,040 l of salt water with a concentration of 83 g/l. Dynamic level 1200 m, static 600 m;
- the interval 2102 – 2090 m Helvețian – discharged 165,000 l of salt water with a concentration of 135 g/l. Dynamic level 1300 m, static 850 m;
- the interval 1982 – 1962 – Swiss – discharged 85,250 l of salt water with a concentration of 105 g/l. Dynamic level 1400 m, static 800 m; Due to the technical situation of the well, no conclusive results were obtained from the Upper Badenian and Sarmatian horizons.

Layer tests carried out at **4141 Bendiu** provided the following data:

- 224,700 l salt water (concentration 90 g/l) with Nd=325 m and Ns=100 m were obtained from the Oligocene formations (interval 2250 - 2234 m) by pistoning;
- from the Helvetian deposits (depth 2052) 141,000 l of salt water with a concentration of 19 g/l, with Nd=150 m and Ns=75 m were pistoned. Testing of the Buglovian deposits showed the presence of flammable gases with a pressure of 5 atm.

Mineral water structures at Sîngeorz – Băi. In Sîngeorz - Băi the research of the structures with mineralized waters started in the seventies: Slăvoacă (1966) and Lungu (1974) apud VELICIU (1989). In the limestones of the middle Eocene and in the sandstone formations of the upper Eocene is hosted a deep aquifer complex, under an impermeable roof consisting of a thick marl horizon, attributed to the upper Eocene, and having an artesian character. The aquifer discharges mineralized waters that emerge from some springs and boreholes from Sîngeorz - Băi with temperatures that significantly exceed 12 °C. Thus, the water in borehole 4 ISPIF, (with a depth of 173 m), has 13.7 °C. Borehole 2 ISPIF, (with a depth of 174 m), shows 14.5 °C, and borehole F4111 IFLGS is characterized by a temperature of 14.7 °C. The other mineralized springs in the resort have lower temperatures: 11.5 °C for F1 ISPIF and 10.3 °C for spring number 3. The mineral water deposit at Sîngeorz Băi is located in the sandstones of the lower part of the Eocene in a Brachyanticline. The water stored here dissolves CO2, which migrates to the surface on the Someșului fault, a fault that also favored the placement of the rhyodacitic intrusion. An input of thermalized water from the depths, also coming on the Someș fault, which would explain the higher temperature of the emergences, is not excluded.

Hydrochemical data. Hydrochemical considerations on natural emergences in the territory of Bistrița - Năsăud County are based on the combination of data concerning geological and hydrogeological conditions with those concerning the chemical composition of water. For this purpose, archival data were used, selecting a number of 90 analyses.

The hydrochemical data are combined with the other prospecting data to determine the genesis, circulation and accumulation conditions of the waters in the region. In addition to the study of the chemistry of the mineral waters, the chemical composition of the free gases accompanying the mineral waters in the Sîngeorz - Băi area was studied, as well as their radioactivity.

Temperature measurements for the waters of Sîngeorz - Băi were carried out both in winter and summer. In summer the temperatures at emergence are between 11°C and 16°C, while in winter the measurements at 4 springs show values ranging from 6 to 10.3°C.

Due to the presence of salt formations in its geological composition, the Bistrița - Năsăud county includes a large number of saline springs. The salty mineral waters are characterized by the presence of chlorine, sodium, potassium, bromine and iodine ions in high concentrations. Thus, at Beclean - Băile Figa the total mineralization reaches values ranging from 112.6 to 319.8 g/l, with chlorine and sodium ions in a proportion of almost 99%.

Due to the presence of gypsum, some sulphate-sulphurous springs also occur. The H2S content varies between 0.5 and 21.6 mg/l.

The determining factor to which the Someșul Mare Basin in general, and the Sîngeorz - Băi area in particular, owes its quality as a region with mineral waters, is the presence of carbon dioxide emanations, the last form of manifestation of neogene volcanic activity.

From a chemical point of view, the mineral waters of the deep aquifer complex are clearly distinct from the carbon dioxide mineralized vadose waters. The deep waters of Sîngeorz - Băi and Anieș show a sodium bicarbonate, bromiodoped sodium bicarbonate chemistry specific to "metamorphosed" waters, formed over a long period of time, in closed structures or with extremely slow circulation, in which water mixing and ion exchange may have occurred. The presence in these waters of iodine (with values ranging from 0.2 to 0.5 mg/l), bromine (up to 3 mg/l) and low sulphate content indicate the participation of organic matter in the mineralisation process. The carbon dioxide produced by post-volcanic exhalations gives these waters a carbonaceous character.

The chemical composition of groundwater expresses the chemical equilibrium that is established between the chemical nature of the water, the rocks in which it is hosted and the dissolved carbon dioxide, under internal conditions of temperature and pressure. With the rise and appearance of these waters at the surface in the form of springs, the temperature and pressure conditions change, producing a sudden imbalance which causes the deposition of calcium carbonate in the form of calcareous tuff. The total mineralisation of these waters rarely exceeds 2-3 g/l, of which the dissolved CO2 can reach up to 1.2-1.8 g/l. Thus, CO2-mineralised ford waters have a simple chemistry: calcic-magnesian bicarbonate, sometimes calcic-sodic bicarbonate, on top of which the carboglacial character is superimposed.

The free gases accompanying the mineral waters in the Sîngeorz - Băi area, both those belonging to the deep mineralised aquifer complex and the carbonaceous ford waters, have a similar chemical composition, in which more than 98% CO2 predominates (Table 1), thus indicating the unique source of carbon dioxide mineralising the waters of the region.

The radioactivity of the mineral waters of Sîngeorz - Băi has also been determined (Table 2). Thus, the water of springs 4 and 5 has a high content of both radon and radium. The water of spring 6 is weakly radioactive. These results confirm the hypothesis that the water of springs 4 and 5 is not connected via the nipple to the water of spring 6. As it rises to the surface, it loses some of its radon as it releases CO2. The high radon content suggests the presence of a deep circulation, most probably on the fault called "Someș fault".

CONCLUSIONS

After inventorying the existing data, for the region of the Bistrița - Năsăud County, in general, and for the area of Sîngeorz - Băi, in particular, and after verification and observations made in the field, we can reveal the following positive aspects (CONSTANTINA et al., 2021).

Based on the pre-existing information from hydrocarbon wells (bottom temperatures, temperatures of productive strata, thermocorotages), temperatures in the range of 60°C - 80°C at depths of about 2000 m were recorded in the Bistrita county.

The representation of temperature values obtained from measurements in 40 short geothermal prospecting boreholes (50 m deep) oriented N-S, perpendicular to the major geological structures in the region and two other boreholes located in the Dragoș stream valley led to the delineation of thermal anomalies, one of which is located at Sîngeorz - Băi.

Taking into account the fact that water temperatures in emergent areas (springs and boreholes) varying between 10 and 15°C have been recorded in the Sîngeorz - Băi area, on the fault that limits, to the south, the crystalline massif of Rodnei, it indicates that these temperatures exceed the average air temperature at the ground surface (8 - 10°C), being suspected of a thematic water supply from depth, distributed on preferential areas, including the area subject to the present research.

For Sîngeorz - Băi, the application of the method for the study of the silica content of mineralized emergences whose solubility is temperature-dependent resulted in depth temperatures above 70°C. The temperatures of the emergences can be considered as the minimum temperature of the convective system, while the equilibrium temperature of the silica is a suggestion of the water temperature at depth.

By making the two regional maps (geothermal flow map, rock temperature map at 2000 m depth) highlighting the possibility of the existence of conductive geothermal systems, a higher potential and geothermal flow anomaly represented by the Someș fault is noted in the studied perimeter.

The geothermal flow in the region is quite high, reaching values of 100 mWm-2 in some areas, a maximum that is also maintained in the western part of the area of studdy, which provides positive premises for the location in this area of a geothermal energy exploitation drilling.

By extrapolation, the rock temperature at 2000 m indicates values of about 80 - 100°C.

The central-western area of the Rodna Mountains is dominated by a regional magnetic anomaly, which indicates that there are magmatic sources in the region that can generate thermal anomalies especially in the sector Tatarului - V. Orgii.

On the negative aspects, regarding the existence of a deep aquifer with geothermal water near Sîngeorz - Băi, we point out the following:

The territory of the Bistrița Năsăud county has not been the subject of systematic geothermal research, the only observation data on the temperature in the subsurface at depth coming from measurements made on the gas-bearing structures, or in the 2 deep boreholes executed by IFLGS (4141 - Beudiu and 4135 Bistrița).

The conclusions of VELICIU's 1989 report estimate that the average thermal gradient is 20 - 25°C per kilometre, and the temperature at depth reaches values of 60 - 70°C at 3000 m for the Bistrita area, a fact confirmed by measurements made in boreholes Bistrita 4135 and Beudiu 4141.

The permeable deposits, belonging to the Transcarpathian mudstone, which could be host rocks for geothermal aquifers, do not have sufficient thickness, composition, permeability or fissuration for a possible geothermal aquifer to have a flow rate for efficient exploitation.

Consequently, the most favorable area for geothermal and hydrothermal potential is in the western part of the U.A.T. Sîngeorz - Băi, an area with faults, high thermal gradient, and high potential for deep aquifer confinement. A previous borehole was drilled, but unfortunately, access to its data was restricted. A possible positive result, in that period, unlikely to have been overlooked.

Given that there are currently no clear indications that deep aquifer structures with geothermal water but with a good geothermal gradient exist in the region, we consider it appropriate to locate vertical heat pumps as an environmentally friendly and renewable source of energy.

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