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The Erma Reka Low-Enthalpy System (S-Bulgaria) – Geothermal Characteristics

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ABSTRACT

Bulgaria is a small country situated within the Balkan Peninsula. The country is quite rich of geothermal resources. There are more than 700 explored springs with temperature up to 103^{o}C in about 140 sites.

The Erma Reka geothermal system belongs to the most interesting and prospective in Bulgaria and Balkan Peninsula with respect to reservoir conditions.

A big geothermal anomaly, the widest and unique for the country, was discovered during the geological and hydrogeological investigations of non-ferrous metals in the region of Erma Reka and Allamovtsi village during the period 1955-1956. It is a result of combination of various factors: geological structures, tectonic faults, paleo- and neo-tectonic lifting up of the massif, thermal characteristics of the rocks, etc. To clarify this anomaly, 60 deep structural hydrogeological drillings were made to a depth of more than 1500m. As a result of the investigation, it was established that a thick marble horizon exists in the region of Erma Reka and Malka rivers over an area of about 30 sq.km from elevation +100 m down to elevation –2000m. The upper part of the marble horizon is about 40 m thick and is strongly cavernous. The marbles can be said to be unevenly enkarsted. Several drillings found vertical failures 500 m to 1250 m deep, filled with thermo-mineral water of about 90ºC temperature. The hot water in the region has a permanent piezometric level at elevation +490m. On the Bulgarian territory, there are no surface expressions of hydrothermal activity, such as hot springs and altered rock, while on the territory of neighbor Greece, the geothermal water overflows at elevation +430 m into the Elidze river bed, with a temperature of 60-70ºC.

Careful study of the Erma Reka geothermal system is a key for proper exploitation and planned wide activity. It makes an excellent subject of many further researches for sustainable use of geothermal water resources in the cross-border region and utilization of the thermomineral waters in Bulgaria in the flow rates, which will not cause negative impact on the Greek side.

The work carried out in the Erma reka geothermal system consisted of geological and hydrogeological mapping, geophysical investigations and water sampling of thermal springs, located on Greek territory, and wells for geochemical analysis. Silica and cation geothermometers were applied to predict possible subsurface temperatures. The equilibrium state of thermal waters was studied by means of log Q/K diagrams and Na-K-Mg triangular diagram. It was found that water with temperature 100-150^{o}C could be obtained by drilling.

1. INTRODUCTION

Bulgaria is situated within the Balkan Peninsula. Two main tectonic structures, the Moesian platform and Alpine-Himalayan belt are well distinguished on its territory. The territory of the country is a complex mosaic of platform and raised areas, deeply tectonized with extensive lithological variations and multiple magmatic manifestations. Bulgaria is mostly rich in thermal waters with temperatures between 25 and 105°C. Magmatic and metamorphic rock complexes and comparatively rare sedimentogenic complexes are accumulators of these waters. Watersheds of surrounding mountains are assumed as boundaries of separate basins because it is considered that they very often coincide with those of underground waters. There are several low-enthalpy geothermal systems being subject of exploration and exploitation in Southern Bulgaria. Among them is the Erma reka geothermal system, where since the 1960s the intense hyfrogeological and hydrogeothermal research works have been carried out. The so far results indicate that it belongs to the most complex, interesting and prospective low-enthalpy systems in Bulgaria.

The geological investigations of the Erma reka region have been conducted for over 100 years as the geological structure of the natural resources forms a very attractive sector of the Rhodopa massif. Investigations carried out since 1959 and mainly since 1963 by numerous scientists include geological studies, geophysical survey, drilling, including completion tests of wells, and geochemical exploration. Geological, hydrogeological and geochemical studies have led to the identification of mighty aquifer of thermomineral water in the immense marble's dome hosted in Precambrian gneiss's complex.

The report focuses on geological, hydrogeological and thermal features of the Erma reka system and on geochemical interpretation of chemical data of hot spring, located in Greece, and well discharges. Calculation of reservoir temperature using various geothermometers was carried out. Solution-mineral equilibrium has been used in an effort to understand the physical processes, which take place in the geothermal system. The maximum predicted temperatures are 100-150°C in the marble Pre-Cambrian Complex. This is a brief, but complex view on the system, summarizing over 40-year's hydrogeological investigations.

2. GEOLOGICAL SETTING

The Erma reka geothermal system is situated in the south of Bulgaria, within south part of Madan ore basin, Central Rhodopa massif. It is located near town of Zlatograd. It takes surface about 30 km^2. In terms of structure, the territory of the system falls into the Rhodopa structural zone. The Rhodopa massif holds a remarkable place in the Bulgarian geothermal panorama and in the Balkans. The main part of it is built by ancient metamorphittes and granites, cut off and dislocated by a dense system of active and seismic faults. It was fragmented into three parts in the early Paleozoic. The massif was raised during the Alpine orogeny. Several acidic (rhyolitic) eruptions took place during the late Paleocene and several thin depressions (volcano-sedimentary) developed mainly to the east. The western and central parts were raised during the Neogene and Quaternary periods and a network of faults appeared which are still active. In this geological area some impressive unstratified hydrothermal systems are formed and are still active.

3. MAIN FEATURES OF ERMA REKA SYSTEM

3.1 Geological features

Information obtained from more than 1200 bore-holes drilled in the region was used for clarification of the complex geological-tectonic, hydrogeological and geothermal conditions.

The Erma reka region is built of two main lithostratigaphic complexes: Archean and Proterozoic methamorphic complexes. The Archean complex consists of carbonate rocks - mainly marbles of immense thickness - over 1000 m, gneisses and amphibolites, schist.

The Erma reka geothermal system is a complex tectonic structure, consisting of Precambrian metamorphic complexes, Upper Cretaceous granites, Paleogenic sediments and volcanites. Gneisses, granito-gneisses, marbels and volcanites have the widest spreading in the region (Figure 1).

It is related to marble dome inserted in a Precambrian gneiss complex. The marble horizon, with silicatizated cavernous zone formed in its upper part, underlying gneiss complexes at a depth over 450 m. The thickness of the marbles is over 1000 m. The bedrock is not undercut by wells yet. Marbles do not have natural manifestation on the surface of the territory of the country.

Results obtained from the deep structural wells drilled in the Erma reka system indicate about very complicated geological body built of marbles, interbeded by silicate rocks. The structure is additionally complicated by three main fracture groups oriented into different directions: west-northwest 275-305º; south-southeast 60-80º and east-west 90-100ºC and so called Ermenski fault oriented to northeast-southwest. The high-angel faults form the complicated block structure of the region. Marbles are karstified and cavernous and they shaped very complicated hydrothermal system accumulating confined thermomineral waters Thick quartz cavernous zone is formed on the boundary between the marbles and gneisses lying over them.

3.2 Hydrogeological features

The Erma reka hydrothermal basin is a very complex geological phenomenon. The geological-structural and the lithological-facial peculiarities of the Erma reka system favour the formation of two water-bearing systems: hydrogeological systems developed in the silicate metamorphic and igneous complexes bearing fissure type of waters and carstic waters, accumulated in the fractured and carstified Pre-cambrian carbonate marble massifs and layers.

Quartz cavernous zone and cracked marbles accumulate pressure thermal waters which ascend through the numerous faults to the gneiss complex and by this heat the rock massif. A natural hydraulic relation exists between cold and low-heated fissure waters, with free water table disposed in gneisses (zone of regional cracking), and pressure waters accumulated in the quartz cavernous zone. The cavernous zone drains deeper parts of the marble horizon as well as the underlying gneisses.

The Precambrian marble horizon has been uncovered through 70 structural wells. From the beginning of geological invesrigation more than 1300 wells were drilled, 120-125 of which subject of hydrogeological studies.

Numerous survey and structural wells drilled in the region as well as ore shafts and adits driven have lead to significant changes of the natural regime of the ground waters. The interaction between the two water-bearing complexes was changed due to appearance of direct paths for infiltration of waters into the marble horizon. It was detected that the water level is situated at shallow depths in case of drilling only in gneisses, without going into the quartz zone and permeable faults. The water level decreases rapidly to the piezometric level of the thermal waters immediately after entering into the cavernous quartz zone. The thermal water piezometric level occurs at different depths measured from the surface depending on several factors: number of faults in the cavernous zone, location of wells, relief and seasons.

Hydrogeological pumping-test has been carried out on 78 wells. The results obtained indicate that hydrogeological parameters vary in wide interval and in practice they characterized the filtration properties of the quartz cavernous rocks, marbles and gneisses complex. The coefficient of permeability varies between 60m^2/d and 15000m^2/d, the coefficient a (piezotransmission) changes in the range from 1.10^4 to 11.10^{6}m^2/d. These results confirm heterogeneous filtration peculiarities of the water-permeable rocks in horizontal and vertical direction.

3.3 Surface manifestation

The geothermal system possesses distinct surface manifestations only on Greek territory. There is a shapely zone of 20 thermal wells located in the Ilidza river valley at about 8 km south-southwest from Erma reka valley. The basin contains several major faults, which act as the main drainage system Thermal springs are situated along a well-defined contact of a fault, following the Ilidza river valley, with silicate metamorphites. Thermal springs were captured in 1942. The biggest one, located in the centre of the spring group, possesses flowrate 5,3 l/s and temperature 52ºC. The temperature of the neighbour spring with a flowrate of 3,6 l/s is 53ºC. The flowrate of remaining springs vary in the range between 0,03 l/ and 2,25 l/s and the temperature – between 21ºC to 48ºC. It is assumed that the total flowrate of the spring group amounts to 60 l/s.

The varying conductivity of the tectonic zones and irregularities, and the network of criss-crossing irregularities create very complex routes for the circulation of the thermal waters and hydraulic connection between the fissure systems.

3.4 Thermal features

Formation of hydrothermal system Erma reka is favour from one side form the optimum combination between geological structures with tectonic dislocations, heat parameters of the rocks, intensive and long-term hydrothermal activity Petrov, P., An.Andreev, etc., (1971). However this explanation does not give an account of from one side the larges sizes of the heat rock massif, and from other hand – the peculiarities of distribution of the anomaly geophysical field. The idea that the system is influenced by the heat impact of secondary magmatic center of Paleogenic magmatizm is launched lately.

The geothermal anomaly embraces significant for its scale heat rock massif. It is assumed that it includes not only the region of Erma reka, but the whole area of the Madan ore field. Source with power heat potential of immense size is needed for heating of such large massif. Additionally a genetic relation regarding the heat source for the whole massif exists.

In Erma river valley and Malka reka river valley a thermal anomaly was detected. It is a result of combination of several factors: geological structures, tectonic faults, paleo and neo-tectonic uplifting of the massif, grooving erosion, heat properties of the rocks, grooving physic-chemical processes, hydro-thermodynamic conditions, long time hydrothermal activity. In the central part of the anomaly, at absolute level “0” is measured rock’s temperature about 100ºC. In the most west part of the region, at depth 1345m (absolute level “-344”) it is measured temperature of 128ºC.

The temperature conditions of the region are mainly formed of water flow. The strong influence of underground waters on the temperature conditions is clearly expressed from the variation of geothermal gradient values. The values of geothermal gradient in the Erma reka region are several times higher than the average value of the geothermal gradient of 3ºC/100m. The highest values of the geothermal gradient were detected in the central part of anomaly where marbles and thermal water-bearing quartz cavernous zone are widespread.

The thermal heat flow possesses maximal values in Erma river valley. For the central part of anomaly, in the complex of biotite gneisses laying over the marbles (around horizon +400 m) it amounts to about 670 mW/m^2 (there are measurements of about 200 mW/m^2) Petrov, P. (1994). For parts of the thermal anomaly, where the water-bearing quartz zone is not spread, the values of the heat flow are 3-4 times smaller. Too indicative is the fact that the heat flow in marbles is 10-15 mW/m^2. So estimated conductive heat flow in gneiss complexes is 40-50 times bigger than this estimated in marble horizon that means that heat transfer in marbles, especially in the quartz cavernous zone is mainly convective. The average geothermal gradient varies between 4 and 17ºC/100m in the gneiss complexes. It is usually about 1ºC/100m and in very rare cases from 0 to 0.5ºC/100m in the marbles. The highest temperatures of horizons +450m and +50m are 70ºC and 94ºC respectively as they are connected to the most uplifted parts of the marble horizon. Apart from heat convection within the. aquifer, this fact can be explained by increased upflow of hotter fluids from the deeper part of the system along the planes of discontinuities

3.5 Geochemistry of the geothermal water

The physical properties and chemical composition of thermal waters from the Erma reka-Ilidze geothermal system are listed in Table 1.

The chemical composition of the thermal waters depends on lithology of the water-bearing rocks, relief, the depth of hydrodynamic and temperature zones. High temperatures, gases and paleohydrothermal processes of formation of ore mineralizations have been exercised influence on the chemical composition of thermal waters.

More than 400 hydrochemical analyses of samples taken from structural and exploration wells and workings, springs have been made. Based on these analyses for the composition and properties of the waters it was found that the chemical composition and physical properties of thermal waters accumulated in the marble horizon differ considerably from those of waters accumulated in silicate rocks. The composition of thermal waters is mainly bicarbonate-sodium, sulfate- sodium or potassium. The total dissolved solid is repeatedly higher that the mineralization of the cold water from the zone of active circulation. It vary in wide range - from 0,6 g/l to 1,43 g/l. Thermal waters are mainly alkaline - pH varies from 6.4 to 8.6. Waters contain very high concentration of dissolved H_2SiO_3 acid - up to 255 mg/l. The micro-chemical composition of thermal waters is varied. The content of F reaches 8mg/l, Li – 1,6 mg/l, Sr – 0,4 mg/l, Zn – 0,7 mg/l, etc. It was detected presence of gas - He in more than 2 volume%.

A triangular diagram based on the relative concentrations of the major anions, i.e. Cl^-, SO_4^{2-} and HCO_3^- is used for the classification and characterization of the natural thermal waters, for discern immature unstable waters (Figure 3). The compositional range in the diagram is indicated for one group of thermal waters, such as peripheral. Most of the samples plot in the high bicarbonate region with a slight tendency to steam heated water. The diagram provides an initial indication of mixing relationships and allows the exclusion of unsuitable waters for cation solute geothermometers.

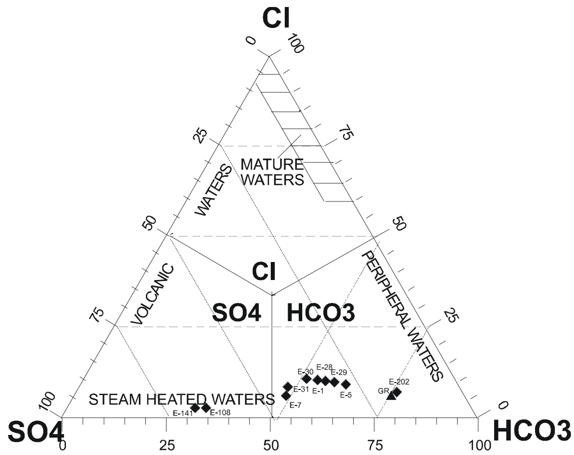

Figure 3: Cl-SO4-HCO3 diagram for the Erma reka geothermal system waters

Figure 4 shows the plot for the Erma reka-Ilidza geothermal system on the Giggenbach triangular diagram. The diagram was used to evaluate equilibrium conditions between the geothermal water and reservoir rocks. All samples plot on a straight line in the area of immature waters which represents Na-K temperature between 200°C and 250°C, very close to the Mg corner of the diagram. The behavior of the Erma reka samples and their location in the Na-K-Mg diagram may be explained either by mixing or by water-rock reactions during through flow.

K-Mg equilibration temperatures were calculated (Giggenbach, 1988) indicating a source temperature ranging from 20°C to 49°C. On the other hand temperatures ranging from 186°C to 256°C were found using the Na-K geothermometer (Giggenbach, 1988). Because the K-Mg system equilibrates faster than Na-K, the temperatures obtained from K-Mg geothermometer may indicate shallow conditions of mixing with groundwater. Assuming no additional reactions at shallower levels, Na-K thermometer may reflect source conditions. Assuming cooling by adiabatic processes SiO_2 geothermometer has been applied. A complete range of equilibration temperatures using solute geothermometers is given in Table 2.

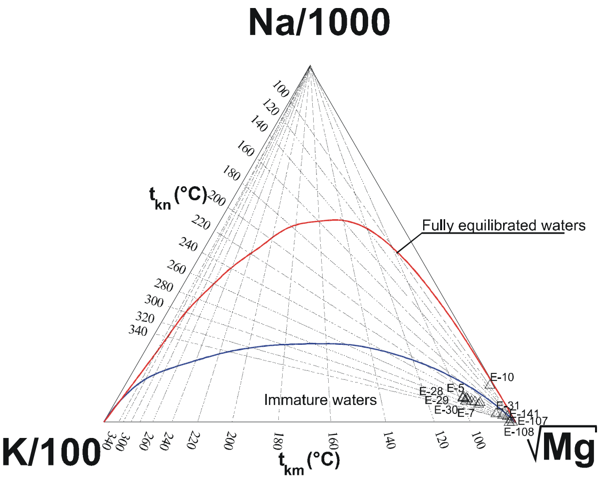

Figure 4: Na-K-Mg triangular diagram for the Erma reka geothermal system waters based on Giggenbach (1988)

The chemical composition of 12 geothermal wells and one spring in the Erma reka-Ilidze geothermal system were interpreted by using the WATCH program (Bjarnason, 1994), which gives information about the mineral equilibrium. The equilibrium temperature was calculated on the basis of the equilibrium temperature values corresponding to log Q/K=0, for albite, Ca, Na and K montmorillonite, calcite, analcime, chalcedony, quartz, adularia and microcline. The equilibrium is slightly perturbed, probably due to the mixing of thermal waters with cold waters at different temperatures. Most of the minerals calculated are found to be fairly close to saturation of chalcedony temperature.

4. GEOTHERMAL RESOURCES AND THEIR UTILIZATION

The estimation of natural and exploitation resources of Erma reka geothermal system is very difficult and complicated. The schematization of the hydrogeological and hydrogethermal conditions made, even proved by a lot of facts hide too many conventions. Because of the established hydraulic connection between waters accumulated in gneiss complexes and marble horizon, calculations were made for the whole underground space accumulator of gravitation underground waters. The natural resources of underground water accumulated in gneiss complexes are evaluated to $167x10^6m^3$. The volume of the natural resources accumulated in the quartz cavernous zone and in marbles amounts to $27x10^6m^3$. The elastic recourses constitute about 12-13% from the natural resources of the system and they amount to $20x10^6m^3$. The dynamic resources represent the natural dynamic flowrate of the fissures and fissure-karstic waters distributed mainly in the zone of regional fissuration of the gneiss complex. For the whole geothermal system the dynamic resources are assessed to about 60 l/s.

The Erma reka geothermal system heat potential is the biggest one among the Rodopa massif.

At the moment only about 10 l/s are being utilized. Over the last few years the country has been suffering from energy deficiency, which makes it all the more important that non-traditional sources of energy, including geothermal, should be utilized to their full potential. The possible applications of the thermomineral waters are: balneology and prophylaxis, swimming pools, bottling of natural mineral water, greenhouses, fluorite preparations and concentrates, spas, central heating (with heat-pumps), drinking water supply.

5. DISCUSSION AND CONCLUSIONS

Erma reka geothermal system is located near the town of Zlatograd in South Bulgaria. It takes an area of $30km^2$. It was investigated through 60 deep structural hydrogeological wells, vertical shafts, horizontal mine workings, ground wells, etc.

Granite-gneisses were discovered to +350 m depth from the surface.

Marble horizon of immense thickness, over 1000 m, underlay gneisses. Marble water-bearing horizon is not exposed on the surface. It takes part in construction of an anticline structure broken in separate blocks connected to faulting zones. Pre-Proterozoic tectonic disruption with north-east direction, so called Ermenski fault, divides the horizon in two tectonic blocks – northwest and southeast. The northwest marble block wrap up steeply in depth in west and north direction. The southeast block is delaminated at short distance in east direction. Both marbles blocks are hydraulically connected and they present comparatively limited fault-stratum structure for accumulation and flow of underground thermal waters.

Both marbles blocks overlay and they are covered by water-tight relatively gnesses that appear to be bottom and overlying aquiclude. Waters accumulated in the marble blocks are connected with the surface only through the permeable fault structures cutting the overlying aquiclude.

The geothermal system is supplied through the infiltration of atmospheric and surface waters. Thermal water-bearing horizon and highly permeable qartz-cavernous zone laying under the thick gneiss stratum accumulate huge amount of hot pressure waters with temperature reaches up to 130ºC. The configuration of the hydropiezometric water surface indicates that in the Erma and Malka rivers valleys where there is a permeable quartz zone strongly developed over the marbles hydropiezes are settled at the lowest levels 480-510m. The water flow is oriented to the rivers flow. In the highest part of Erma reka region where marbles lay at big depth and the cavernous quartz zone is missing, the piezometric surface of thermal waters is settled at high absolute levels – over 600 m. The water drainage is on the Greek territory – in Ilidza river valley. All springs are connected to the ore-bearing structures with east-west direction.

Hot pressure water accumulated in the marble horizon appears to be main reason for the existing of hydrogeothermal anomaly in the region of Erma reka river valley. The marble horizon appears to be second, regional, heat source in the general geothermal field. The natural temperature regime in depth that is characterized with temperatures increased with depth secure continues conductive heat flow to surface. Simultaneously, the temperature gradient decrease significantly in the marbles. Thus the heat anomaly is connected to the influence of vertical convection provoked by the ascended to the surface water flow. The last one is drained into the quartz cavernous zone and eventually in part of its underlying adjoining marbles and in overlying gneisses, forming as a whole a drainage zone of Erma reka region. Generally under the drainage zone the heat transfer is mixed – conductive and convective.

The water-bearing drainage zone is characterized with irregular filtration conditions. As a whole the filtration flow is almost horizontal.

The composition of the thermal and sub-thermal waters discovered is mostly bicarbonate-sodium, sulfate-sodium and bicarbonate-sulfate-sodium. The bicarbonate-sodium waters are connected to the marble hydrothermal zone. They are slightly mineralized, highly alkaline, as their pH is in the range 8-9. The sulfate-sodium and sulfate-calcium waters are mainly accumulated into the gneiss formation of the Pre-Proterozoic complex.

The chemical geothermometers, which have been used to estimate the subsurface temperature of the geothermal water, give an overall picture of the Erma reka-Elidze geothermal system. The K-Mg geothermometer gives low temperature values for the thermal waters and generally it can not be used alone. The Na-K geothermometer gives high temperature values for the thermal waters and generally it can not be used alone. Results of Na-K-Ca geothermometer indicate that this empirical geothermometer appears to be applicable for low-temperature waters. As a whole, there is relatively good correlation between Na-K-Ca, crystobalite and chalcedony temperatures. In the Erma reka-Elidze geothermal system almost all wells draw fluid from two or more water horizons and discharge mixed water. The quartz geothermometer yields higher temperatures than the average temperature of the mixed water. The chalcedony geothermometer provides the most reliable temperatures for the basin.

The similarity between equilibrium temperatures for some of the wells suggest that these wells draw fluid from the same aquifer, but at different depths and consequently in different proportions. Based on these results it can be concluded that the equilibrium temperature is 50-70^{o}C for the gneiss horizon and 120-150^{o}C and even higher for the marble horizon.

Assuming that the 3000m deep formation is the hot water aquifer and that 100-120^{o}C is the source temperature we get a geothermal gradient 3.3-4^{o}C /100m for the study area. The almost normal gradient means that the water is heated only because the aquifer goes deep enough to reach the temperature estimated by chalcedony, Na-K and Na-K-Ca geothermometers.

The known thermal water-sources are not utilized to their full potential

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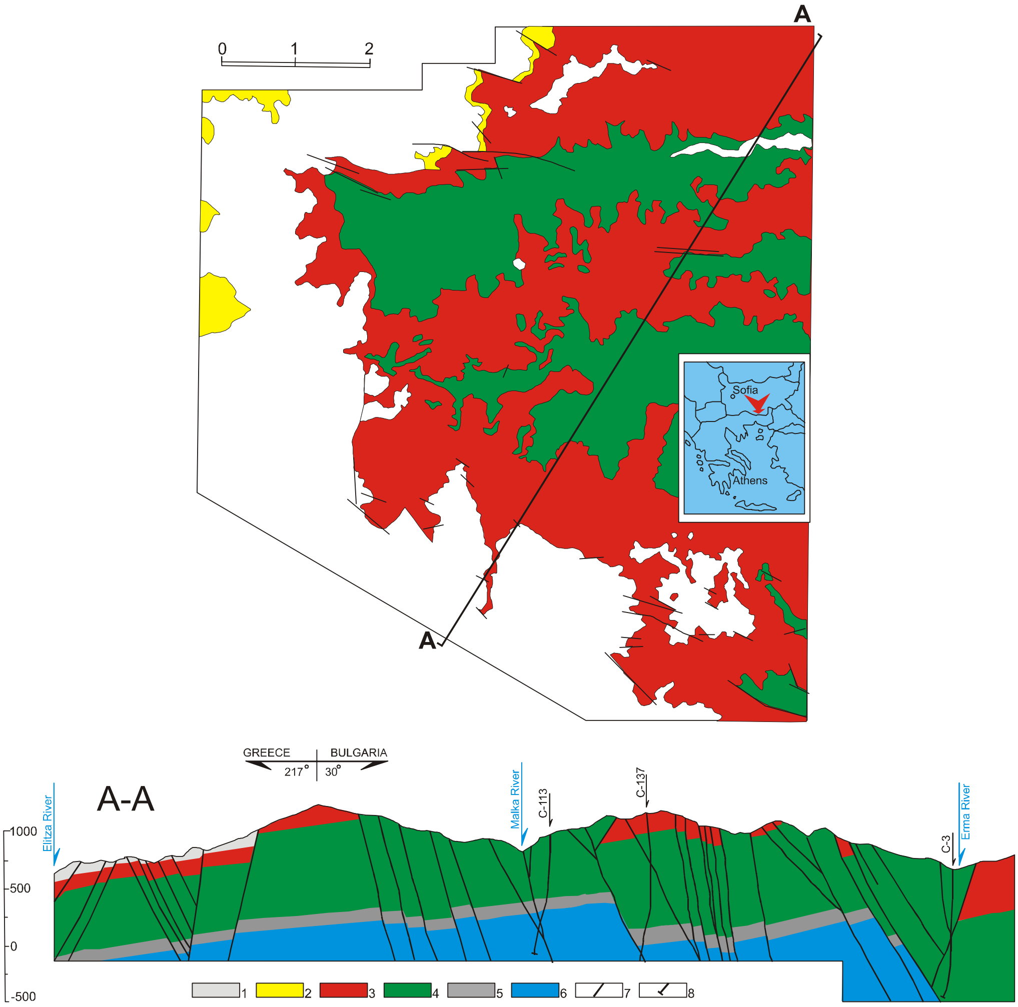

Figure 1: Geological map of the region located between Erma River valley and Elitza River valley

Legend: 1. Lower mixed suite; 2. Suite of marbles and amphibolites; 3. Granite-gneisses suite; 4. Suite of biotitic gneisses and amphibolites; 5. Leucocratic suite; 6. Carbonate suite; 7. Fault; 8. Structural well

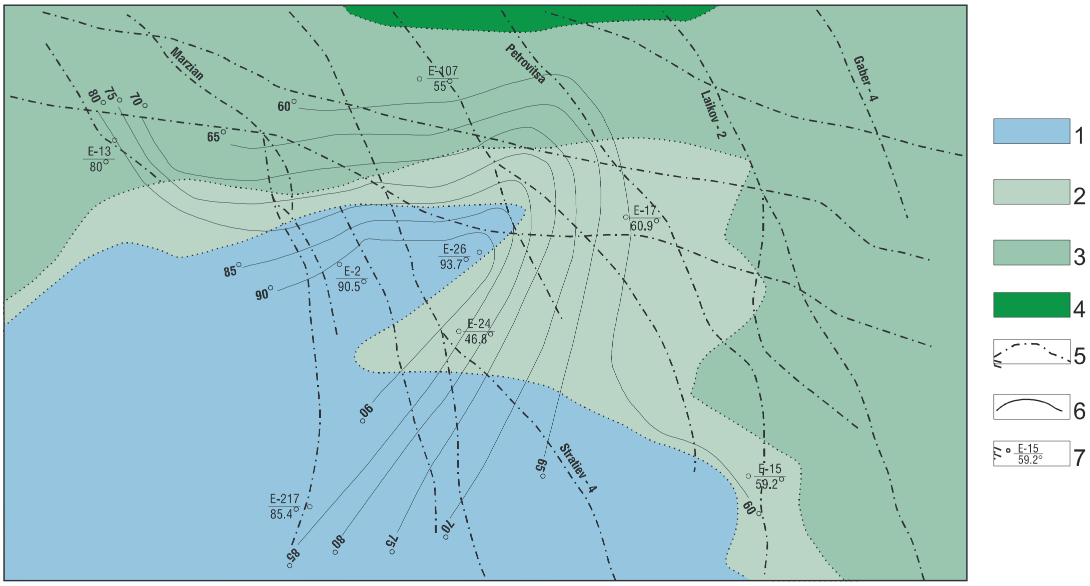

Figure 2: Geothermal map of the Erma reka geothermal system – horizon +450 m

Legend: 1. Granite-gneisses; 2. Biotitic gneisses; 3. Muscovite gneisses; 4. Marbles; 5. Faults; 6. Izotherms; 7. Well – number and measured temperature

Table 1. CHEMICAL COMPOSITION OF THERMAL WATERS FROM THE ERMA REKA GEOTHERMAL SYSTEM

Locality	Well Number	TDS	pH	Na	K	Ca	Mg	Cl	SO4	CO2	SiO2	F	Al	Fe
		ppm		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Erma reka geothermal system - Bulgaria	E-5	1254.5	8	212	26.5	56	9	65	197	331.2	176.33	-	0.1	0.03
	E-7	379.4	7.3	65	6.4	33	1	8	165	43.2	30.8	1.5	0.19	0.027
	E-28	1068.3	7.6	203	24.3	29	6	58	185	244.8	167.09	6	0.092	0.028
	E-29	1095.6	8	186	24.6	40	5	57	176	258.48	190.96	-	0.178	0.027
	E-30	1022.2	8.3	193	24.2	20	6	56	191	211.78	183.26	-	0.084	0.025
	E-31	938.9	8	138	17.9	63	9	45	225	195.12	130.9	-	0.08	0.08
	E-35	842.3	7.6	115.7	13.3	52	9	43	156	213.12	110.88	-	6.96	0.418
	E-107	231.7	7.3	19	1	33	1	6	45	63.36	29.26	0.7	0.63	0.042
	E-108	422.7	6.8	32	2.9	77	2	7	179	66.96	22.33	0.8	0.78	0.234
	E-138	1085	7.4	187	1.6	61	6	59	157	215	20	4		
	E-141	706.7	7.2	18	1.1	171	4	8	369	74.88	23.87	0.6	1.34	0.02
	E-Sh1	1003	8.3	197	24	24	5	56	184	211.08	164.78	6	0.044	0.026
	E-2003	1425.25	7.1	215	26	100	6	65	212	403.92	178.5	3.8	0.117	0.012
Ilidza River - Greece	Spring	1378.17	7.2	170	20	138	8	51	153	468	140.91	3.3	0.54	0.076

Table 2. INFORMATION ABOUT THE ERMA REKA GEOTHERMAL SYSTEM

Main type of reservoir rock Cavernous, cracked marbles

Locality	Well Number	Estimated Reservoir Temp. (°C)						Measured Reservoir Temp. (°C)	Log Q/K Temp. (°C)
		$T_{ch.}$	T_{qtz}	T_{Na-K}	$T_{Na-K-Ca}$	$T_{cristob.}$	T_{K-Mg}		
Erma Reka - Ilidze	E-5	144	172	213	121	122	22	57	98-176
	E-7	52	80	186	69	31	25	38.5	42-98
	E-28	141	168	208	135	118	21	79	102-176
	E-29	150	177	220	125	127	20	68	112-184
	E-30	147	174	214	145	124	21	67.5	112-159
	E-31	125	153	218	97	102	25	57.4	91-149
	E-35	115	143	203	89	92	27	-	112-196
	E-107	50	78	128	11	29	42	17	45-102
	E-108	39	68	177	26	18	35	21	34-96
	E-141	42	70	140	-	21	48	16,5	36-92
	E-Sh1	143	170	203	109	120	23	87	92-161
	E-2003	145	172	209	105	122	20	87	118-170
Ilidza River - Greece	Spring	130	157	206	85	107	24	48	98-155

Table 3. GEOTHERMAL ENERGY IN THE ERMA REKA GEOTHERMAL SYSTEM

Geothermal system "Erma reka - Ilidza"	Flow Rate	Measured Temp.	Temp. lowering to 15°C		
			Heat power	Tonnes oil equivalent/y	Value effect
	l/s	°C	10^{10} kJ/y	t/y	$/y
In case of dynamic flow not influenced on the water drainage in Greece	15	89	14.63	3494.99	2621242.5
	20	89	19.51	4660.77	3495577.5
In case of re-injection of used thermal water	50	89	48.77	11650.74	8738055
In case of total dry up of the massif	100	89	97.53	23299.1	17474325