*Proceedings World Geothermal Congress 2000*
*Kyushu - Tohoku, Japan, May 28 - June 10, 2000*

# STRUCTURE AND GEOTHERMAL POTENTIAL OF THE BOURGAS HYDROTHERMAL BASIN, BULGARIA

Sylvia Georgieva[1] and Ivan Vlaskovski[2]

[1]Research Institute "Geology and geophysics", Sytnjakovo Blvd. 23, 1505 Sofia, Bulgaria

[2]Geonica Ltd., Jambolen 2, 8600 Jambol, Bulgaria

**Key Words**: structure, geothermal, geochemistry, Bourgas hydrotherrmal basin

## ABSTRACT

Six hydrothermal fields and nine hydrothermal occurrences are available in the Bourgas hydrothermal basin. The area does not contain many surface expressions of hydrothermal activity, such as hot springs and altered rock. The temperature of the waters is within the range of 20°C to 49°C. Because of its special geological structure, the total dynamic resources of the thermal and sub-thermal waters were estimated at about 110 l/s. Exploitation is still on a very limited scale, 47% of the geothermal potential of the basin, and the basic application is related to baths and spas and for bottling potable waters. The work carried out in the Bourgas hydrothermal basin consisted of geological and hydrogeological mapping, geophysical investigations and water sampling of thermal springs 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 the Na-K-Mg triangular diagram. It was found that water with temperature 80-100$^{o}$C could be obtained by drilling.

## 1. INTRODUCTION

Bulgaria is situated within the Balkan peninsula. Its territory is within two main tectonic structures, the Moesian platform and Alpine-Himalayan belt. The terrain of the country is a complex mosaic of platform and raised areas, deeply tectonized with extensive lithological variations and multiple magmatic manifestations. It is quite rich in thermal waters with temperatures between 25 and 105°C. In Southern Bulgaria there are several basins and areas with thermomineral waters. 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 groundwater divides. Based on the hydrogeological conditions the country is divided into six regions, one of which is the Sredna Gora region. The Sredna Gora region is divided into several hydrogeological structures. The main one is the Bourgas synclinorium filled with volcano-sedimentary formations of Upper Cretaceous age to a thickness probably up to 3000 m.

The interest in underground waters in the Bourgas hydrothermal basin dates back a thousand years. Ruins from the Roman Empire are found near the Bourgas mineral baths (Termopolis, Terma, Metali therma), near the Pirne village (Pirnous) and in other places. The basin has been a subject of investigations of foreign specialists from the XVII to the end of the XIX century (Hadji Kalfa, Ami Boue, Hochsteffer, Irechec and others). Investigations carried out since 1933 and mainly since 1954 by numerous scientists include geological studies, geophysical survey, drilling and completion tests of wells, and geochemical exploration. Geological, hydrogeological, and geochemical studies have led to the identification of six hydrogeothermal fields and nine occurrences in the Upper Cretaceous volcano-sedimentary formations in the fractured systems of the adjacent mountain ranges; and in the Upper Cretaceous underlying the Bourgas depression (Figure 1).

The report focuses on geological and hydrogeological features of the basin and on geochemical interpretation of chemical data of hot spring 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 that take place in the geothermal system. A good agreement is obtained for the estimated reservoir temperature using different methods. The maximum predicted temperatures are 100-120°C in the lower part of the Upper Cretaceous Complex. In the Triassic and Jurassic sediments of the region, waters with temperatures up to 150°C can be found.

## 2. GEOLOGICAL AND HYDROGEOLOGICAL FEATURES OF THE BOURGAS HYDROTHERMAL BASIN

The Sredna Gora structural zone is developed on a heterogeneous foundation of Precambrian metamorphic rocks, batholiths of Paleozoic granites, and Triassic and Jurassic sediments. This deep trough is filled with sediments and also volcanic rock (andesites) of the Upper Cretaceous age. Most of the sediments in the zone are flysch. The whole complex of sedimentary and volcanic rocks is folded and dislocated. It is divided into several hydrogeological structures and basins of diverse dimensions, shapes, lithology and stratigraphy. Specific hydrogeological features are related to the Upper Cretaceous volcano-sedimentary formations and Neogene-Quaternary depressions.

In terms of structure, the area of the Bourgas hydrothermal basin falls into the Eastern Sredna Gora structural zone, i.e. the Bourgas synclinorium. It is a part of an extremely fractured and declining (in the earth's upper crust) area. To the north and south it borders with deep fractured structures, the rear Balkan fracture and the North Strandja Flexure. To the west, the border is not so clearly marked by disrupted structures. To the east the structure is open.

The Bourgas synclinorium is a complex rift or island-arc structure, consisting of Upper Cretaceous sediments, sedimentary-volcanogenic complexes and volcanites of immense thickness, which gets thicker to the east, towards the Black Sea, and is divided into four series. Sedimentary complexes are dominated in its southern parts. The central area is made up of volcanogenic rocks. In certain parts of the region, deposits of Paleogene, Miocene, Pliocene and

Quaternary sediments are found covering the Upper Cretaceous complex (Figure 2).

Two very different structural zones can be distinguished in the tectonic make-up of the synclinorium. A northern zone, where the pattern consists of blocks and folds. It is characterized by rather complex combinations of Paleo-volcanic formations and folds deposited at a later time, with a variety of disruptions cutting through the folds. The southern zone is monoclinal and very fractured and comprises a complexity of fissures. They are a result of mid-Alpine deformations, which affected the greater part of the Upper Cretaceous rocks. The tectonic movements are of a block-faulted nature. The first significant faulting took place after the Turonian, right before the start of the volcanic activity. The zones of volcanic activity and the linear character of the volcanic structures are greatly controlled by the faults with their general northeast-southwest orientation. The late Alpine tectonic movements are of a block-faulted nature too. As a result, several structures were deposited over the structures of the Upper Cretaceous Sredna Gora zone. The most significant of them were instrumental for the formation of the Bourgas hydrothermal basin and the overlying Bourgas depression. This tectonism also created the conditions for the formation of a number of important faults and grabens.

The Bourgas hydrothermal basin is a very complex geological phenomenon. The geological-structural and the lithological-facial peculiarities of the Bourgas synclinorium favour the formation of the following aqueous horizons and complexes: the Quaternary, Pliocene, Miocene and Paleogene aquifers, and the Upper Cretaceous aqueous complex. The Upper Cretaceous complex takes up the largest area as it is practically found in all parts of the synclinorium. It is a hydrogeological environment with a fissure-type collector. The porosity and permeability of the monolithic rocks is negligible. The water is connected to the weathered crust and the disruptive irregularities. This accounts for the remarkably high filtration and geothermal diversity of the basin, for the distribution of its hydrothermal fields, and for the fields themselves. The basin contains several major faults, which act as the main drainage system. The first one is connected to the hydrothermal fields Poljanovo, Aitos, Sadievo, and probably the Bourgas spas. The Medovo hydrothermal field is connected to a group of shorter fractures.

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.

Fissure- and layer-type waters are present in the deeper levels of the complex. In the geological profile of the basin features one can identify two clearly defined hydrothermal zones which differ considerably in their genetic, geochemical and energy characteristics: an upper (infiltration) zone and a lower (elision) zone. The upper hydrothermal zone is located in the volcanogenic formation of the Bourgas series and its waters are formed in the filtration environment created by lithogenic and tectonic fissures. The composition of the thermal water is mainly bicarbonate-sodium. It is only slightly mineralized, highly alkaline. It can be expected that strongly mineralized waters with an interesting composition have formed in the deepest layers of the lower hydrothermal zone at high temperature (over 100°C) and hydrostatic pressure. The basin drains into the Black sea and into the negative parts of the relief which contains plenty of fissure areas. In some of them, the thermal waters are released naturally, like the thermal spring at Bourgas spas; in others some drilling was required to bring the waters out, such as Polyanovo, Aitos, Sadievo, Medovo and Sunny beach hydrothermal fields

## 3. GEOCHEMISTRY OF THE GEOTHERMAL WATER

The physical properties and chemical composition of thermal waters from all the six geothermal fields in the Bourgas hydrothermal basin are listed in Table 1.

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 thermal waters (Figure 3). The compositional range in the diagram is indicated for several groups of thermal waters, such as peripheral, mature, and to some extent, volcanic waters. The diagram provides an initial indication of mixing relationships and allows the exclusion of unsuitable waters for cation solute geothermometers. The most suitable group comprises neutral, low sulfate, high-chloride geothermal waters, which plot along the $Cl^-$-$HCO_3^-$ axis and in chloride corner (thermal waters from Sunny beach field). The data from Polyanovo thermal water plot in two fields. Samples B-111, B-135 and B-136, which are the hottest, are close to mature waters although a little high in sulfate (chloride water with a sulfate component). The other samples are bicarbonate-chloride water. The Bourgas spas hot waters seem to be more closely related to the Polyanovo than to Aitos and Sadievo thermal waters. All samples plot near to the mature waters. The Aitos and the Sadievo waters plot in peripheral waters. The Medovo waters also plot in two groups. Some of them plot in mature waters similarly to Sunny beach waters and the others are a bicarbonate-chloride water.

Figure 4 shows the plot for the Bourgas hydrothermal data on the Giggenbach triangular diagram. All the samples plot on a straight line which represents Na-K temperature between 50-120°C. Most of the samples follow the curve “Fully equilibrated water” and some of them fall into the partially equilibrated waters field. The behavior of the Bourgas 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 24°C to 61°C. On the other hand temperatures ranging from 36°C to 135°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, $SiO_2$ geothermometry has been applied. A complete range of equilibration temperatures using solute geothermometers is given in Table 2.

The chemical composition of 30 geothermal wells in the Bourgas hydrothermal basin 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

As a rule, the hydrothermal fields and occurrences in the Bourgas hydrothermal basin offer limited resources. The most powerful of them is the Polyanovo hydrothermal field. The total thermal energy potential of the basin is calculated to 21.7 kJ/y. This is equivalent to saving about 5194 tonnes oil per year, or $525,903 (Table 3).

At the moment about 54.4 l/s are being utilized, which is 47% of the total flow available. 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 thermal - mineral 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

In hydrogeological terms, the Bourgas hydrothermal basin falls into the category of basins with nitrous thermal waters in the Mesozoic and Tertiary sedimentogenic and volcanogenic rocks of the Southern Bulgarian mountain ranges and inter-mountain artesian basins.

Genetically, the Bourgas hydrothermal basin is fissure-based, which accounts for its hydraulic and filtration diversity and also for the localization of the thermal water flows in the "open" fissure areas and the connection of the hydrothermal surface manifestations with their drainage areas.

Thermal water fields gravitate towards fractured drainage areas, which are responsible for the off-load of thermal waters with temperature up to 50°C.

The composition of the thermal and sub-thermal waters discovered is mostly bicarbonate-sodium, chloride-sodium, chloride-sulfate-sodium and bicarbonate-sulfate-chloride-sodium. The bicarbonate-sodium waters are connected to the upper hydrothermal zone in all geothermal fields. They are slightly mineralized, highly alkaline, as their pH is in the range 8-10. The Sunny beach and Medovo chloride-sodium waters, accumulated into the flysch formation of the Upper Cretaceous complex, are of juvenile origin. They are not affected by seawater inflow.

The chemical geothermometers that have been used to estimate the subsurface temperature of the geothermal water give an overall picture of the Bourgas hydrothermal basin. The K-Mg geothermometer gives low values for the thermal waters and generally it cannot be used alone. Results of Na-K-Ca geothermometers indicate that this empirical geothermometer appears to be applicable for low-temperature waters. As a whole, there is relatively good correlation between Na-K, Na-K-Ca and chalcedony temperatures. In the Bourgas hydrothermal basin almost all wells draw fluid from two or more aquifers 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 probably 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°C for the upper (infiltration) zone and 100-120°C and even higher for the lower (elision) zone.

Assuming that the 3000m deep formation is the hot water aquifer and that 100-120°C is the source temperature we get a geothermal gradient 3.3-4°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.

Apart from the Bourgas Spas, the known thermal water-sources are not utilized to their full potential.

## ACKNOWLEDGEMENTS

Many thanks to our colleagues Georgy Mihailov, Valentina Mihailova, Peter Nedev and Bojidar Denkov for the geothermal data collection.

## REFERENCES

Bjarnason, J.O. (1994). The speciation program WATCH, version 2.0. Orkustofnun, Reykjavik.

Bontchev, E. (1971). Geotectonic problems in Bulgaria. Sofia, Ed. Technika.

Cheshitev, G, and Kanchev, I. (editors). (1989). Geological map of Bulgaria, scale 1:500 000.

Giggenbach W.F. (1988). Geothermal solute equilibria. Derivation of Na-K-Mg-Ca geoindicators. Geochim. et cosmochim. Acta 52, 2749-2765.

Mihailov, G., Teneva, S. et al. 1995. Analysis, interpretation and summary of data for the Upper Cretaceous complex and assessment of prospects for underground water searching in the Bourgas region. (Final report). Ministry of Environment.

Teneva, S. (1994). Chemical geothermometry and fluid/mineral equilibria of waters in the NW-Bourgas synclinorium, Bulgaria. Report 14 for the UNU Geothermal Training Programme, Orkustofnun-National Energy Authority, Reykjavik, Iceland, 30pp.

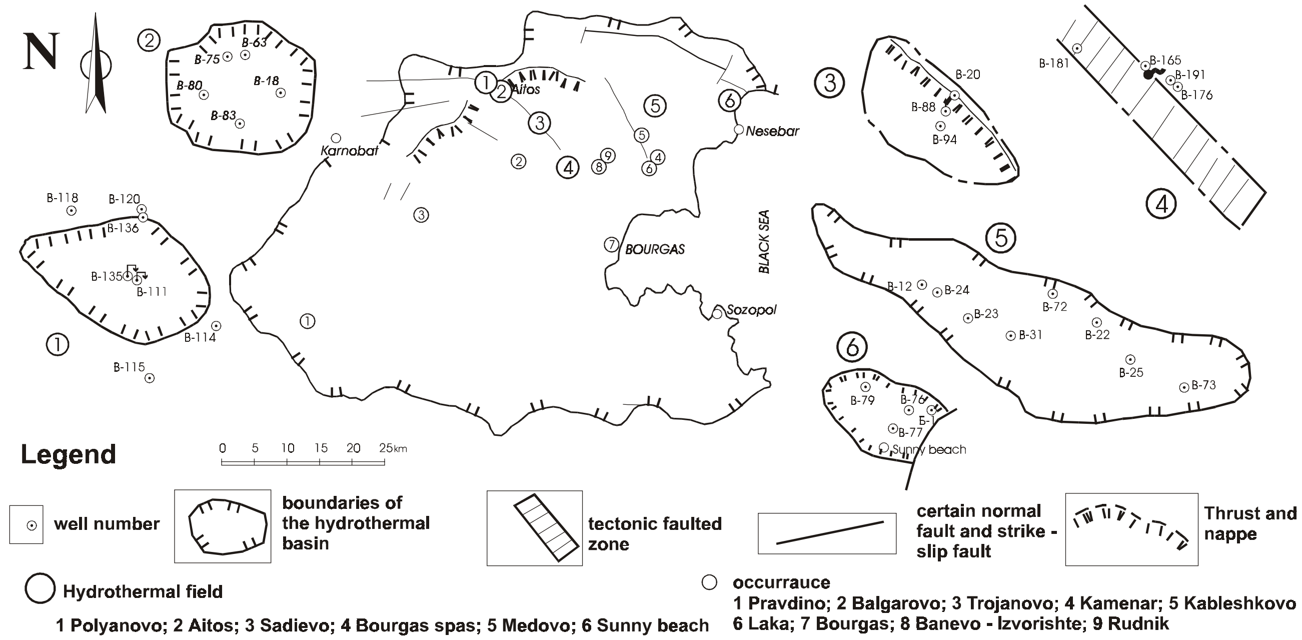


Figure 1. LOCATION OF THE HYDROGEOTHERMAL FIELDS AND OCCURRENCES IN THE BOURGAS BASIN

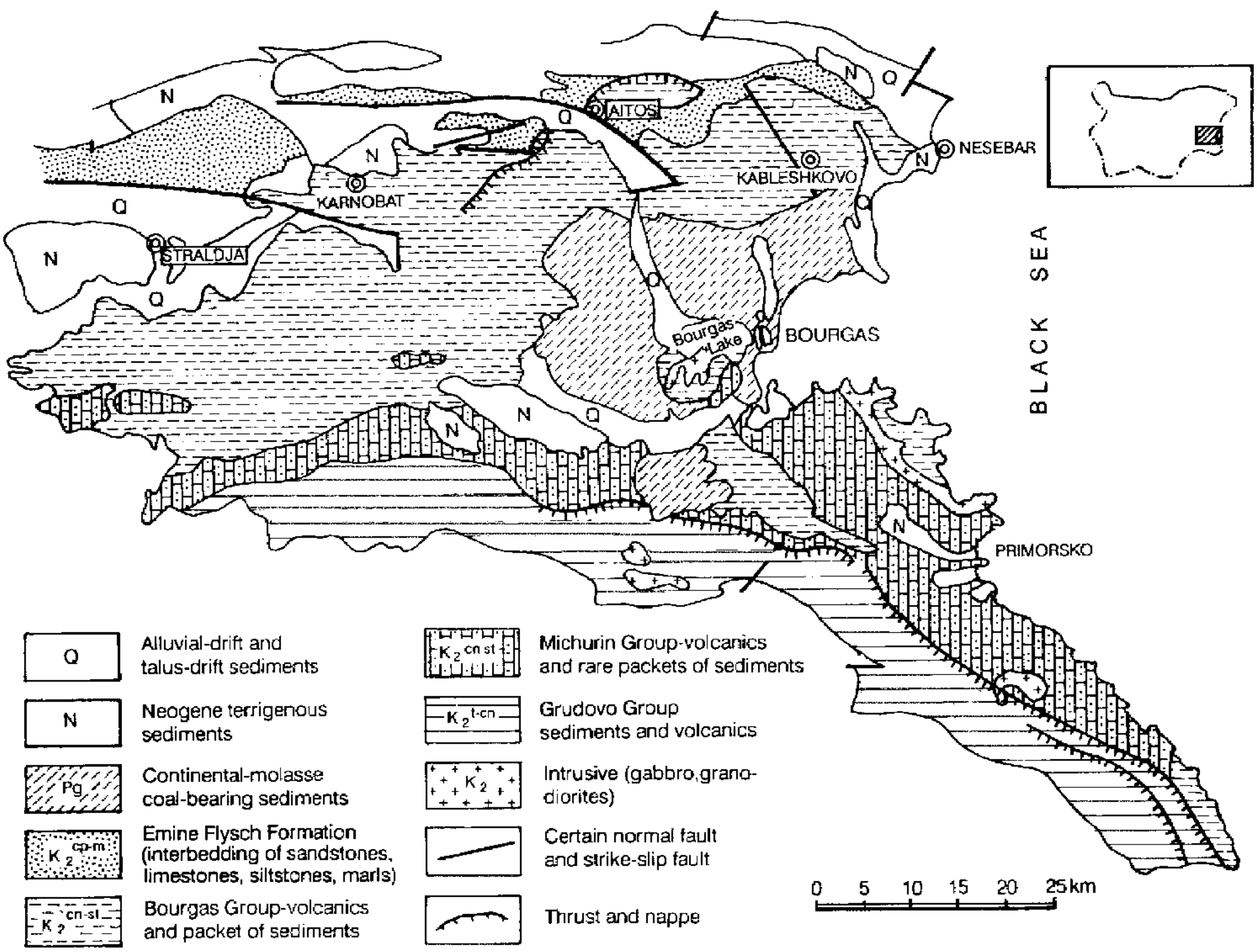


Figure 2. GEOLOGICAL MAP OF THE BOURGAS SYNCLINORIUM (Cheshitev and Kanchev, 1989)

Table 1. CHEMICAL COMPOSITION OF THERMAL WATERS FROM THE BOURGAS BASIN

| Locality | Well Number | TDS ppm | pH | Na ppm | K ppm | Ca ppm | Mg ppm | Cl ppm | SO4 ppm | CO2 ppm | SiO2 ppm | F ppm | Al ppm | Fe ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Polyanovo | B-111 | 745 | 9.6 | 232 | 0.9 | 3 | 0.2 | 167 | 161 | 44 | 73 | 10 | 0.381 | 0.0076 |
| | B-114 | 633 | 8.6 | 187 | 0.7 | 12 | 3 | 138 | 118 | 80 | 31 | 8 | 0.124 | 0.124 |
| | B-115 | 604 | 7.9 | 186 | 0.4 | 5 | 7 | 127 | 110 | 98 | 18 | 5 | 2.79 | 0.028 |
| | B-118 | 734 | 8.3 | 72 | 1.6 | 88 | 27 | 49 | 106 | 229 | 19 | 1.8 | 0.294 | 0.018 |
| | B-120 | 807 | 8.3 | 187 | 1.6 | 34 | 13 | 94 | 127 | 215 | 20 | 6 | 0.338 | 0.034 |
| | B-135 | 666 | 9.5 | 204 | 0.9 | 4 | - | 168 | 128 | 42 | 59 | 10 | 0.133 | 0.0066 |
| | B-136 | 592 | 9.1 | 192 | 0.4 | 5 | - | 158 | 123 | 40 | 25 | 10 | 0.41 | 0.176 |
| Aitos | B-18 | 540 | 8.9 | 146 | 0.6 | 2 | - | 25 | 52 | 163 | 58 | 8 | | 0.498 |
| | B-63 | 538 | 7.9 | 132 | 0.9 | 3 | 0.6 | 40 | 58 | 153 | 62 | 2.5 | | 0.0046 |
| | B-75 | 443 | 8.4 | 110 | 0.9 | 5 | 2 | 34 | 53 | 131 | 42 | 1.8 | | 0.011 |
| | B-80 | 501 | 8.8 | 140 | 0.8 | 2 | 1 | 25 | 51 | 149 | 53 | 4 | 0.21 | 0.0042 |
| | B-83 | 884 | 9.2 | 240 | 3 | 4 | - | 76 | 132 | 182 | 134 | 2.8 | 4.31 | 0.026 |
| Sadievo | B-20 | 369 | 9.3 | 90 | 2 | 2 | 1 | 19 | 18 | 121 | 40 | 7 | | 0.034 |
| | B-88 | 437 | 8.8 | 110 | 0.2 | 2 | 0.6 | 20 | 22 | 142 | 60 | 5.5 | | 0.0073 |
| | B-94 | 570 | 8.4 | 152 | 1.3 | 3 | 1 | 32 | 66 | 154 | 66 | 12 | | 0.015 |
| Bourgas spas | B-165 | 640 | 9.5 | 188 | 1.1 | 4 | 0.6 | 153 | 71 | 58 | 80 | 7.5 | 0.296 | 0.0059 |
| | B-176 | 600 | 10 | 186 | 0.9 | 3 | 0.6 | 155 | 73 | 54 | 82 | 9.8 | 0.12 | 0.042 |
| | B-181 | 622 | 9.5 | 188 | 1 | 3 | - | 146 | 55 | 65 | 84 | 9.3 | 0.006 | 0.006 |
| | B-191 | 600 | 9.9 | 194 | 0.9 | 4 | - | 152 | 73 | 13 | 81 | 9 | 0.012 | 0.0061 |
| | spring | 597 | 9.9 | 189 | 1.9 | 3 | 0.6 | 144 | 70 | 60 | 75 | 10 | 0.061 | 0.061 |
| Medovo | B-12 | 394 | 9.5 | 112 | 1.4 | 1 | 0.6 | 23 | 14 | 113 | 65 | 2 | | 0.106 |
| | B-23 | 409 | 9.4 | 118 | 1 | 1 | 0.6 | 29 | 14 | 111 | 73 | 1.9 | | 0.038 |
| | B-24 | 504 | 9 | 115 | 2 | 5 | 1 | 26 | 19 | 170 | 76 | 2.5 | | 0.082 |
| | B-31 | 908 | 9 | 298 | 2.3 | 4 | 2 | 343 | 17 | 111 | 67 | 2 | | 0.087 |
| | B-72 | 425 | 9.5 | 120 | 1.4 | 5 | 2 | 26 | 15 | 124 | 65 | 1.5 | | 0.012 |
| | B-22 | 2379 | 7.4 | 850 | 1.7 | 39 | 0.6 | 1320 | 18 | 53 | 55 | 2.7 | | 1.45 |
| | B-25 | 2476 | 7 | 904 | 5.1 | 32 | 1 | 1423 | 20 | 22 | 42 | 4.3 | | 0.15 |
| | B-73 | 2160 | 9.3 | 762 | 4 | 20 | - | 1232 | 23 | 24 | 55 | 3.2 | | 0.111 |
| Sunny beach | B-1 | 16168 | 7.5 | 4760 | 36 | 1435 | 33 | 9847 | 6 | 35 | 22 | 2.5 | 0.459 | 0.066 |
| | B-76 | 15900 | 7.4 | 4840 | 31 | 1090 | 106 | 9750 | 14 | 29 | 15 | 2.2 | 0.161 | 0.483 |
| | B-77 | 12822 | 7.4 | 2240 | 25 | 1745 | 660 | 8037 | 20 | 37 | 8.5 | 1.4 | 0.39 | 0.13 |
| | B-79 | 14219 | 7.4 | 4460 | 27 | 755 | 70 | 8794 | 4.1 | 37 | 6.2 | 3.4 | 0.468 | 0.156 |

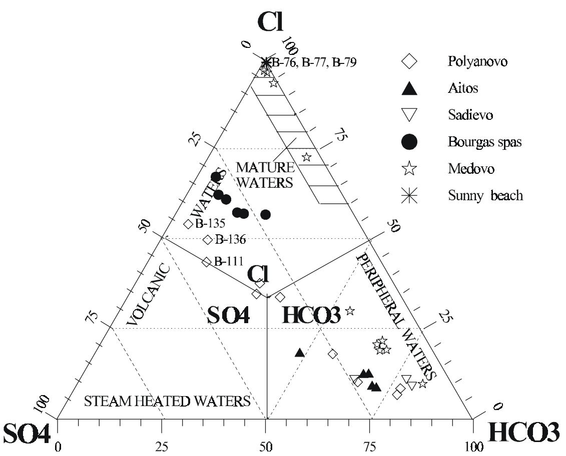


Figure 3. Cl-$SO_4$-$HCO_3$ diagram for the Bourgas hydrothermal basin

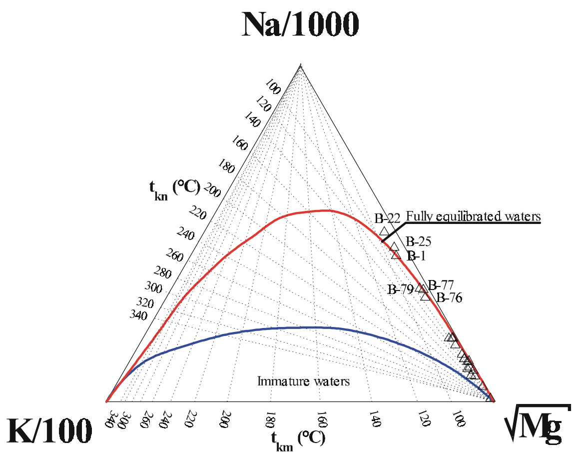


Figure 4. Na-K-Mg triangular diagram for the Bourgas waters based on Giggenbach (1988)

Table 2. INFORMATION ABOUT THE GEOTHERMAL FIELDS

[1] Main type of reservoir rock
FF = Flysch Formation (interbedding of sandstone, limestone, siltstone, marls)
V = Volcanic (tuffs and andesites) and rare packed of sediments
S = Sediments (aleurolits and marls)

| Locality | Rock[1] | Well Number | Estimated Reservoir Temp. (°C) | | | | | | Measured Reservoir Temp. (°C) | Log Q/K Temp. (°C) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $T_{ch.}$ | $T_{qtz}$ | $T_{Na\text{-}K}$ | $T_{Na\text{-}K\text{-}Ca}$ | $T_{Na\text{-}Li}$ | $T_{K\text{-}Mg}$ | | |
| | | B-111 | 92 | 120 | 61 | 71 | 81 | 49 | 49 | 64-110 |
| | | B-114 | 52 | 80 | 60 | 36 | 35 | 33 | 26 | 55-90 |
| | | B-115 | 31 | 59 | 42 | 36 | 44 | 24 | 23 | 50-110 |
| Polyanovo | FF | B-118 | 32 | 61 | 135 | 16 | 123 | 31 | 15 | 45-75 |
| | | B-120 | 35 | 63 | 91 | 39 | 38 | 34 | 18 | 47-75 |
| | | B-135 | 81 | 109 | 65 | 63 | 69 | | 47 | 53-90 |
| | | B-136 | 44 | 73 | 41 | 36 | | | 32.5 | 36-78 |
| | FF | B-18 | 80 | 109 | 63 | 62 | 208 | | 42 | 53-92 |
| | | B-63 | 83 | 112 | 82 | 65 | | 43 | 37.5 | 86-122 |
| Aitos | V | B-75 | 65 | 93 | 89 | 53 | | 37 | 33 | 52-90 |
| | | B-80 | 76 | 105 | 75 | 70 | | 40 | 35.5 | |
| | V | B-83 | 127 | 155 | 107 | 106 | | | 29 | 122-164 |
| | V+FF | B-20 | 63 | 92 | 135 | 96 | | 49 | 29 | 28-59 |
| Sadievo | S | B-88 | 82 | 111 | 36 | 30 | | 29 | 30.5 | 65-105 |
| | V | B-94 | 87 | 115 | 91 | 78 | | 44 | 34 | 81-166 |
| | | B-165 | 97 | 125 | 76 | 69 | 26 | 45 | 30 | 93-105 |
| Bourgas | | B-176 | 98 | 127 | 69 | 68 | 34 | 43 | 41 | |
| spas | | B-181 | 99 | 128 | 72 | 72 | | | 39.1 | |
| | | B-191 | 97 | 126 | 67 | 63 | 33 | | 42 | |
| | | spring | 93 | 121 | 98 | 93 | 341 | 51 | 41 | 73-90 |
| | | B-12 | 86 | 115 | 107 | 102 | | 48 | 29 | 39-69 |
| | | B-23 | 92 | 120 | 91 | 91 | | 44 | 29 | 59-99 |
| | | B-24 | 94 | 122 | 123 | 78 | | 49 | 28.5 | 65-96 |
| Medovo | V | B-31 | 87 | 116 | 87 | 99 | 225 | 47 | 39 | 81-102 |
| | | B-72 | 86 | 114 | 104 | 67 | | 42 | 29 | 39-69 |
| | | B-22 | | | 74 | 83 | 322 | 61 | 36 | 81-111 |
| | | B-25 | | | 74 | 91 | 96 | 59 | 39 | 84-122 |
| | | B-73 | 78 | 107 | 72 | 91 | 30 | | 40 | 88-111 |
| | | B-1 | 39 | 68 | 86 | 90 | | 61 | 32 | 88-120 |
| Sunny | FF | B-76 | 26 | 54 | 79 | 91 | | 53 | 29.2 | 94-115 |
| beach | | B-77 | 6 | 34 | 102 | 66 | | 42 | 21 | 98-119 |
| | | B-79 | -3 | 25 | 77 | 94 | | 54 | 27.5 | 79-93 |

Table 3. GEOTHERMAL ENERGY IN THE BOURGAS HYDROTHERMAL BASIN

| Locality | Well Number | 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 |
| Polyanovo | B-111 | 5.4 | 49 | 2.42 | 578.1 | 58533 |
| | B-135 | 13.7 | 47 | 5.79 | 1383.2 | 140049 |
| Aitos | B-18 | 6 | 42 | 2.13 | 508.8 | 51516 |
| | B-75 | 4.5 | 33 | 1.07 | 255.6 | 25880 |
| Sadievo | B-20 | 16.1 | 29 | 2.98 | 711.9 | 72080 |
| | B-88 | 4.7 | 30.5 | 0.96 | 229.3 | 23216 |
| Bourgas spas | B-165 | 1 | 30 | 1.98 | 47.3 | 4789 |
| | B-191 | 10 | 42 | 3.56 | 851.6 | 86224 |
| Medovo | B-72 | 9.3 | 29 | 1.72 | 410.9 | 41604 |
| Sunny beach | B-1 | 1.4 | 32 | 0.31 | 74.1 | 7503 |
| | B-76 | 3.2 | 29.2 | 0.6 | 143.3 | 14509 |
| | | | Total | 21.74 | 5194.1 | 525903 |