

Potential and Geochemical Characteristics of Geothermal Resources in Eastern Macedonia

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1. Introduction

Geothermal explorations in the Republic of Macedonia were intensified in the 70's, during the first effects from the energetic crisis. As a result of those explorations, there were established over 50 springs with mineral and thermo-mineral water, with maximum potential of over 1400 l/s and evidenced reserves as deposit for exploitation of around 1000 l/s, with temperature higher than the mean season swings for this part of the Earth in the range 20-79 °C, accumulated quantities of geothermal power. Geologically and hydro-geologically spoken, these geothermal resources are mainly located in eastern and southeastern Macedonia, in the Bregalnica-Strumica region composed by 23 municipalities. This region, in its geological past has undergone many big tectonic changes and its composition is formed by almost every type of stones, including the youngest and oldest formations, forming hydro geothermal systems, that currently are the only ones worthwhile to be explored and exploited. The most important hydro geothermal systems in this area are the tertiary basins of Kochani valley, Kezhovica Spa near Shtip, and the Kratovo-Zletovo volcano region, exactly the micro regions included in the REDEM region as the territory from the project target group. In order to valorize this geothermal potential in eastern and southeastern Macedonia certain pre-conditions should be created for using these resources in Bregalnica-Strumica region. This means that serious project documentation should be prepared followed by the targets that should be accomplished and tasks for faster development in order to use this important geothermal potential in this region, but at the same time following the positive legislation for issuing a concession for carrying out Detailed Geological Explorations (DGEs) and exploitation of the geothermal energy in the Republic of Macedonia (RM), according to the Law on mineral raw materials (Official Gazette of the RM, no. 18/99 and 29/02). With the project "Creation of pre-conditions for utilization of the geothermal potential in the eastern and south-eastern region", the basic information about the geothermal resources in the RM will be presented in brief. In addition, the project will present details of the potentials of this region showing the energetic value of the geothermal resources in this region, currently available capacities, technical capabilities and deposit characteristics.

Simple definition of the geothermal energy is that it is a quantum of calories (the thermal energy in warm water) that the Earth holds in its inside part. According to the location

where the geothermal energy is accumulated, in which stratum of the Earth's surface, it can be divided into: hydro geothermal, litho geothermal, magma geothermal and pneumatic geothermal energy. The geothermal energy can be accumulated in the fluids, in the solid rocks, in magma and in gases. Definition of geothermal resource is that it is a part from the Earth's inside heat (higher than the mean annual temperature) that can be exploited, using its economic effect but following the legislation, nowadays or in the near future. Hydro geothermal resources are part of the geothermal resources and presents the part of the Earth's stratum in which apart from the conductive way of transfer of the geothermal energy through rocks as isolators, is also transferred by a convective way among the rocks and their joints that serve as reservoirs, which calories can be rationally used as energy, i.e. exploited. According to the way this geothermal energy is being transferred near the Earth's surface, the hydro geothermal resources are divided in conductive and convective systems.

The group of conductive systems gathers the systems with dominant conductive way of transfer of the geothermal energy. In this group we find the tertiary basins of Ovce Pole, Tikvesh, Delchevo-Pehchevo region, Skopje valley, Strumica valley, Gevgelija valley, Polog and Pelagonija valley (Arsovski and Stojanov, 1995). The group of convective systems is developed in crags, capillary crags and with capillary porosity. Major characteristics of all convective systems are: high hydraulic gradients and high pressures due to the big difference in the heights levels of zones of influx (where the underground water enters the reservoir) and the zones of outflow, where the underground water leaves the pool (Serafimovski, 2001). Before we analyze the geo-thermal potentials of eastern and southeastern Macedonia, we will present the main characteristics of the hydro geothermal resources in the RM.

2. Research methodology

Since the study subject have been terrains with complex geological evolution, an application of complex methodology of field and modern analytical methods, was required which should provide more exact data for realistic interpretation of established goals.

Efforts were made for the first time in this researched area and one large set of geological and non geological data were collected during a longer period of time and studies were conducted along different criteria, their analysis and synthesis by same criteria.

During these studies geological and non-geological methods were used. In regards of geological methods were applied: analysis and synthesis of previous geological studies with special review of tectonic studies, geotectonic concepts and distribution of formations of carbonaceous composition.

These non-geological methods were applied: analysis and synthesis of data from chemical analyses of thermal waters with special attention given to sampling of specimens and applied analytical methods, analysis and synthesis of chemical studies and temperature measurements in realized drill holes.

3. Geothermal resources in Macedonia

Geothermal energy is the warmth that the Earth holds in its inside part. This energy comes from the inner nature of our planet, the physical processes that occur underground. Getting

to and using this warmth is conditioned by a certain carrier - that transports the energy like warmth near the Earth's surface, at considerable depth. This carrier usually is some fluid.

Hydro geothermal energy and resources nowadays are the only ones of the commercially approved sources of energy kept in hot/warm water or steam, accumulated in rock's joints or in porous sedimentary structures at depths going from few hundreds to 4000 m underground. Depending on the temperature and the dominant phase of the fluid, the hydro geothermal resources generally are categorized in 3 groups: low temperature water, mainly used for central heating in homes, apartments, offices, supporting agricultural production in greenhouses (hothouses), and few industrial processes; medium temperature water (<140°C), used in some industrial processes and production of electric energy (using binary cycles-plants that use Freon, known as ORC turbines); and high temperature water or steam (140-350°C) is used for electric energy production in turbine plants (of which 2/3 work in the moderate area 150-200°C).

3.1 Geological characteristics and tectonic placement of the RM

Macedonia is situated in the middle of the Balkans peninsula and has 25.713 km². The geotectonic position is determined by its location. It belongs to the Alps - Caucasus - Himalaya geosyncline belt, and the history in creating of the terrain is tightly connected with the former geosynclinals Tetis and the Alpine orogeny, also with the primordial position of the lithosphere. Generally spoken, over the components of the Alps orogen, the territory of RM belongs on two tectonic systems: the western part including the Vardar valley belongs to the Dinarides (Helenides) whereas the eastern Macedonian mountainous terrain and valley's depressions are segment of the Serbian-Macedonian massif. Additionally, along the Macedonian-Bulgarian borderline, a small separated zone belongs to the Carpatian-Balkanides, the Kraishtide zone (Dimitrievic, 1974).

According to this geotectonic reorganization, the main part of the Macedonian territory that spreads west from the Dojran-Strumica-Zletovo-Kumanovo line is divided in four (4) geotectonic units: Vardar zone, Pelagonian horst-anticlinorium, western Macedonian zone, and the Korab zone better known as Cukali-Krasta zone Fig. 1.

To the East from the mentioned line lies the Macedonian massif of mountains which is connected with the Rodopi Mountains in Bulgaria through the Ograzhden Mountain. In the borderline zone with Bulgaria, to the north of Berovo-Delchevo, as a wedge in the old Rodopi Mountains there are elements from the Carpatian-Balkanides massif separated in the Struma zone (better known as Kraishtide zone, after I. Bonchev). Every separate unit is one structural entity, characterized with its separate geological development including the specific processes of tectonic deformations and manifestation of magma differentiation.

The terrain that forms the territory of the RM in its geological past has undergone big tectonic changes and it is represented by almost every type of rocks, from the oldest to the youngest, starting with Precambrian metamorphosis rocks, with high cristalinity and than the youngest neogenesis and quarter sedimentary complexes. Also, there are found vast surfaces with eruptive rocky masses, from ultra basal to extremely acid and alkaline magma rocks. As a result of all above mentioned, we have found forms with highly specific geological, hydro geological and geomorphologic characteristics. Because of the heterogeneous geologic-lithologic composition and the tectonic past of the terrain as well as

from the different geomorphologic and climate characteristics, there are found different types of underground water. In the mountainous part of the terrain there are more dispersed springs usually found, as opposed to the numerous valleys, there are also springs that are more compactly settled, some with free surface and other under pressure (artesian wells-springs), while in the seismic active zones we find the thermal and mineral waters, i.e. the hydro geothermal resources.

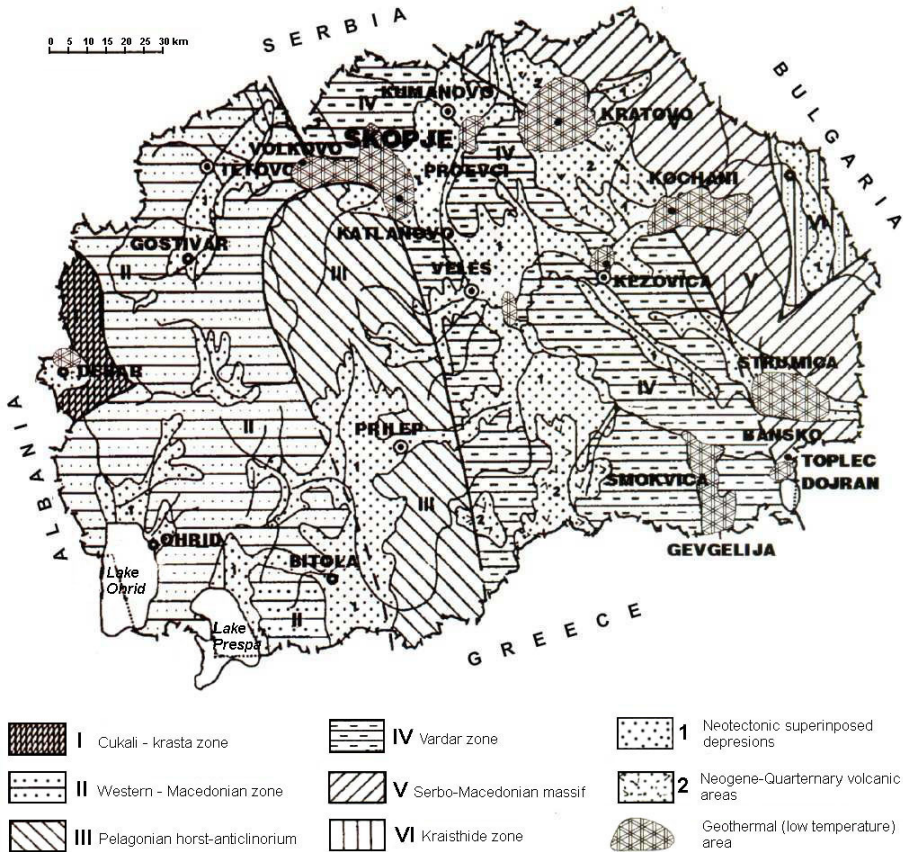


Fig. 1. Main geothermal areas in the Republic of Macedonia and regional tectonic setting (Arsovski, 1997)

3.2 Geothermal characteristics

According to the way of transmission of the geo-thermal energy, hydro-geo-thermal resources are divided in two groups: convective and conductive hydro-geo-thermal systems. The group of conductive systems gathers the systems with dominant conductive way of transfer of the geothermal energy. In this group in the RM we find the tertiary basins of Ovce Pole, Tikvesh, Delchevo-Pehchevo basin and the basins of Skopje valley, Strumica valley, Gevgelija valley, Polog and Pelagonija valley. In the group of convective hydro

geothermal systems a convective way of transfer of the geothermal energy dominates. The most important convective hydro geothermal systems in the territory of the RM are: Skopje valley, Kocani valley, Strumica valley, Gevgelija valley, Kezhovica near Shtip, Toplic-Topli dol on the Kozuf Mountain, Toplec near Dojran, Proevci near Kumanovo, Strnovec, Zdravevci at the river Povishnica near Kratovo, Sabotna voda near Veles, as well as the systems in the western Macedonia - Kosovrasti and Debar spa, and Banice at the river Pena near Tetovo.

In the following text we will present the data and the parameters on the most important hydro geothermal systems in the eastern and south-eastern part of Macedonia. Location of the main geothermal fields and their systems are shown on Fig. 2.

On the Macedonian territory there are rocks from different ages, starting from Precambrian to Quarter, presented by almost all litho logic types. The oldest, Precambrian rocks are composed of gneiss, micaschists, marlstone and orthometamorphides, the Paleozoic rocks are mostly green schists and Mesozoic are presented by marlstone, limestone, acid-, alkali- and ultra alkali magma stones. Tertiary sediments are composed of flysch and lake sediments, sandstones, limestones, claystones and sands. What stands to the structural relations the territory can be divided in six geotectonic units: Chukali-Krasta zone, west Macedonian zone, Pelagonian horst anticlinorium, Vardar zone, Serbian-Macedonian massif and Kraishtida zone. The tectonic position is based upon the terrain itself and the geological data without using geo-thermal hypothesis (Arsovski, 1997). The first four tectonic units are part of the Dinarids, the Serbian-Macedonian massif is part of Rodopi and Kraishtida zone is part of Carpatian-Balkanidi zone.

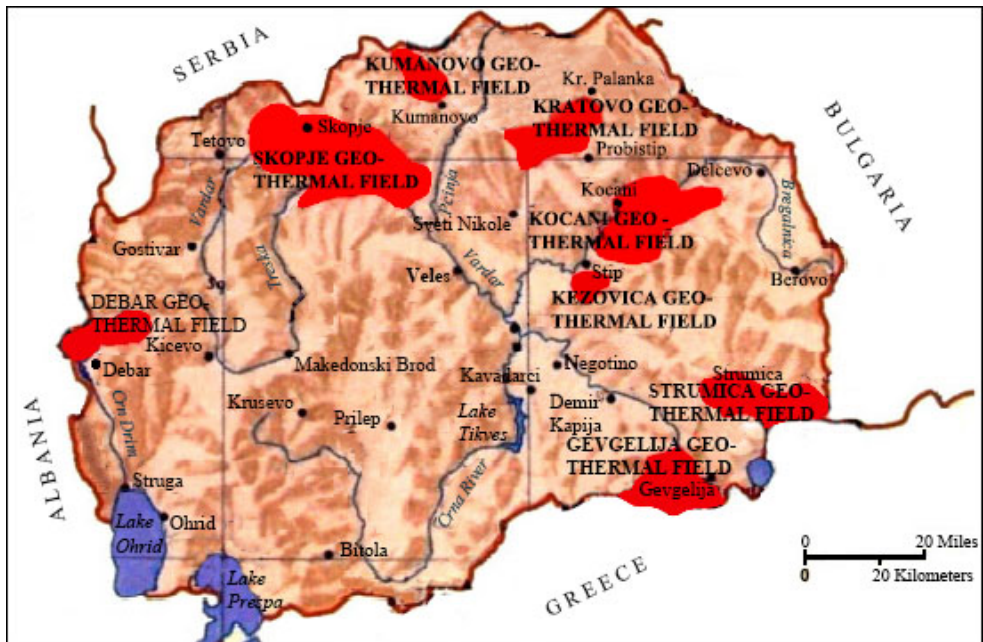


Fig. 2. Main geothermal fields in Macedonia (Popovski & Micevski, 2005)

The territory of the RM as a whole is part of the Alps-Himalayan zone, the Alps sub zone that is still volcanic active. This chain starts in Hungary, runs across Serbia, Macedonia and Northern Greece and all the way to Turkey. Few geothermal regions, including the Macedonian region that is connected with Vardar tectonic unit are set aside. This region shows positive geothermal anomalies. The hydro geothermal systems currently are the only one worthy to be explored and they are exploited. There are 18 geothermal fields known in the country, with over 50 thermal springs, boreholes and hot water wells. The maximal capacity is 1000 l/sec water flow with temperatures from 20-79°C. Thermal water is mostly hydrocarbon according to the dominant anion and equally mixed with Na, Ca and Mg. The concentration of the dissolved minerals stands from 0, 5-3, 7 g/l. All thermal waters in Macedonia are with meteoric origin. The thermal spring is a part from the regional thermal flow, which in the Vardar zone 100-120 mW/m², while in other part of the country is 60-80 mW/m², with 32-35 km thick stratum. The following text will present the details on the data and the parameters for the most important convective hydro geothermal systems in eastern and south-eastern Macedonia, a territory composed of 23 municipalities from Bregalnica-Strumica region.

4. Main geothermal fields in eastern Macedonia that are currently exploited

This presentation will show basic data about the energetic resources in eastern and southeastern Macedonia, current capacities in Macedonia, the technical capability and perspective locations in this part of the country, as well as the methodologies for their valorization from the geothermal aspect.

4.1 Hydro geothermal system of Kochani valley

The geothermal locality "Podlog"-Banja-Kochani is not only important deposit of geo-thermal water in Macedonia, but also in the world (verified with the studies of the American enterprise GeothermaEx and the Austrian consortium ARGE GTM), having in mind the balanced reserves from 157x106 m³ GTW, with exclusively good chemical characteristic, and mean temperature of 75°C. This great potential of the deposit from the aspect of energy, especially the characteristic restorable reserves, has offered the main prerequisite for preparation of the concept, project and implementation of the exploitation system GTW "Geoterma".

The geothermal system "Geoterma" with its installed capacity 300 l/sec exploits and distributes geothermal water to the end users:

1. Heating the Agro-complex - production in greenhouses
2. Low-temperature procedures
3. Central heating of public and administrative buildings
4. Recreation centers and balneology

Basic data for the geothermal deposit Podlog-Banja (geography, morphology, geology, petrology, hydro-geology and chemistry).

Kochani geothermal region i.e. deposit Podlog-Banja is situated in the north-eastern part of Macedonia between the 41° 40' and 42° 00' NGW and 22° 00' and 22° 30' EGL.

Kochani valley with its surroundings is generally spread in East/ West direction and has about 400 km², medium altitude of 330 m. By its morphology the valley is an elongated field

in the medial part of the Bregalnica river basin. The economic, cultural and political center is the city of Kochani (30.000 inhabitants).

The deposit itself in regional-geological sense belongs to the zone of higher thermal flow that stretches from Turkey, across northern Greece, eastern Macedonia all the way to the Panonian basin. In a tectonic sense the region is a complicated orogene area that belongs to the two tectonic units: Serbian-Macedonian basin and the Vardar zone with highly expressed volcanic activity of the Kratovo-Zletovo volcanic area Fig. 3.

The deposit from the point of view of supplementation is an infiltration type.

Based upon the completely done interdisciplinary researches, it is verified as maybe one of the world largest non-magma deposit of geothermal water, with overall balanced static reserves of approximately 150.000.000 m³ over 70°C. The chemistry of the water is Na-bicarbonate water with pH=7, none corrosive enclosed systems, that gives its possibility for various applications. The presence of some elements (Se, F and etc.) in controlled referent limits, gives the water special quality and it can be used as a bottled drinking water (Table 1).

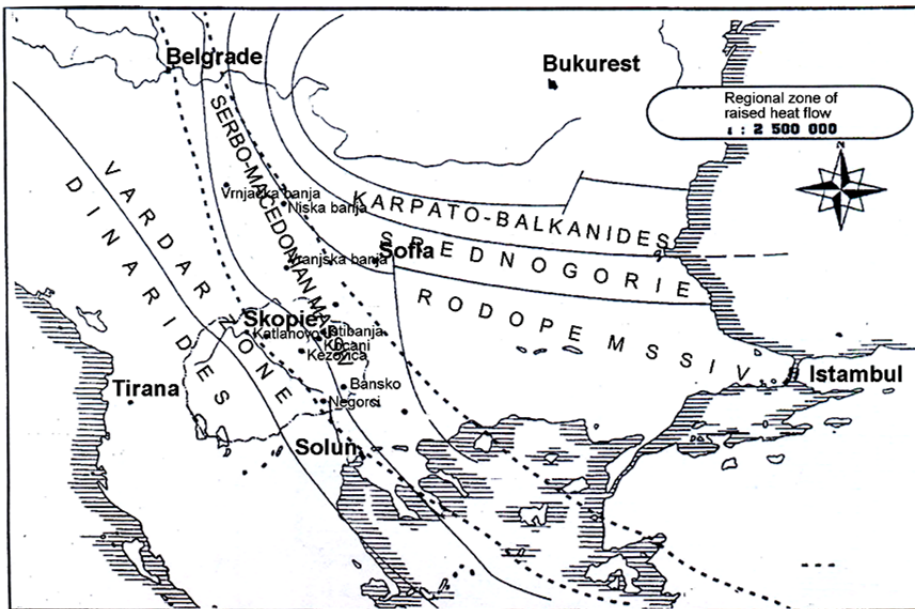


Fig. 3. Regional zone with increased thermal flow (Bonchev, 1974)

In order to take a look on the activities that practically have verified the deposit of geothermal water in "Podlog-Banja" and established the "Geoterma" system, we will present a review, chronology and results organized in three temporal stages (Naunov, 2003).

4.1.1 First stage

The first stage is typically explorative and is located at the very beginning, in the year 1973 and all the way to the year 1984. This period, organized by the Council of the Municipality

| | Name of the chemical substance | Average value mg/l | MDK, for drinking water mg/l |
|----|---|--------------------|------------------------------|
| 1 | Color, Co/Pt | < 5 | 100 |
| 2 | starring, NTU | 0.7 | < 0.6 |
| 3 | dry remrant on - 105 o S, mg/l | 599.6 | - |
| 4 | dry remrant on - 180 o S, mg/l | 620.0 | - |
| 5 | dry remrant on | 493.5 | < 500 |
| 6 | pH - value | 6.99 | 6.8 - 8.5 |
| 7 | p - value, ml 0.1 N HCl/l | 0 | - |
| 8 | m - value, ml 0.1 N HCl/l | 86.4 | - |
| 9 | Bicarbonate ions, [HCO ₃], mg/l | 527.4 | - |
| 10 | total solidity, [VT], o D | 9.27 | - |
| 11 | Carbonate solidity, [KT], o D | 23.02 | - |
| 12 | Calcium solidity, [Ca T], o D | 6.08 | - |
| 13 | Magnesium solidity, [Mg T], o D | 2.90 | - |
| 14 | Chlorides, [Cl], mg/l | 17.9 | 25.0 |
| 15 | Sulphates, [SO ₄], mg/l | 50.38 | 25.0 |
| 16 | Calcium, [Ca ²⁺], mg/l | 48.32 | 100.0 |
| 17 | Magnesium, [Mg ²⁺], mg/l | 11.71 | 30.0 |
| 18 | Total Fe, [Fevk], mg/l | 0.14 | 0.05 |
| 19 | Manganese, [Mn ²⁺], mg/l | 0.019 | 0.02 |
| 20 | Sodium, [Na ⁺], mg/l | 142.4 | 20.0 |
| 21 | Potassium, [K ⁺], mg/l | 18 | 10.0 |
| 22 | Silicon Dioxide, [SiO ₂], mg/l | 44.2 | - |
| 23 | Free CO ₂ , mg/l | 109.8 | - |
| 24 | Aggressive CO ₂ , mg/l | 20.7 | - |
| 25 | Conductivity | 775 | to 300 |
| 26 | Nitrites, [NO ₂], mg/l | 0.0034 | - |
| 27 | Nitrates, [NO ₃], mg/l | 0.29 | 5.0 |
| 28 | Ammonium, [NH ₄ ⁺], mg/l | 0.305 | 0.01 |
| 29 | Phosphate, [P ₂ O ₅], mg/l | 2.29 | 0.03 |
| 30 | Solubler oxygen, [O ₂], mg/l | 5.16 | - |
| 31 | Cyanides, [CN], mg/l | 0.0 | - |
| 32 | Sulphides, [S], mg/l | 0.0 | - |
| 33 | Lead, [Pbvk], mg/l | < 0.01 | 0.05 |
| 34 | Cadmium, [Cd ²⁺], mg/l | < 0.002 | 0.005 |
| 35 | Chromium, [Crvk], mg/l | < 0.005 | 0.05 |
| 36 | Copper, [Cu ²⁺], mg/l | < 0.005 | 0.1 |
| 37 | Zinc, [Zn ²⁺], mg/l | 0.14 | 0.1 |
| 38 | Nickel, [Ni ³⁺], mg/l | < 0.005 | 0.01 |
| 39 | Consumption of KMnO ₄ | 2.13 | to 5 |

Table 1. Summary values of the results from the chemical analyses of the geothermal waters on the locality Podlog - Banja, Kocani (Naunov, 2003)

of Kochani - Study and research office and the Institute on explorative works in mines of RM (Republic of Macedonia), realized by the Geologic institute Skopje and Ljubljana (Slovenia) and GeothermEx (USA), the following researches have been done:

Detailed geologic and hydro-geologic explorations

Detailed structural-petrologic works

Geophysical works (deep geophysics, gravimetric, seismic and shallow geo-thermometric)

Micro location of the exploration boreholes; Based upon the synthesis of all gathered information from the exploration, officially elaborated the following results: the geothermal area in the Kochani valley is being fully characterized in all segments (geologic, petrologic, geophysical, structural and hydro-geological characteristics).

4.1.2 Second stage

Activities in the second stage were mainly organized around promotion of the results and the detailed explorative works from the first stage at the location Podlog-Banja, all with a role of creating an objective ground for establishing a re-injection system. The period of these activities is after 1984 and is characterized with organizing new personnel, at the beginning like an investment group within PCE "Vodovod"-Kochani, and later transformed in an independent experts group of the geothermal system "Geoterma". Since 1984 till present it is the main initiator and animator of the activities concerning the system.

During this period a lot of domestic and foreign experts, also exploration institutions took part and successfully finished the following tasks:

- located and drilled exploiting wells EW MP-1, EW2, EW3 as well as re-injecting borehole P-10, and then in 1999, well EW-4;
- for utilization of the capacities of the deposit 'Podlog-Banja', the concept was prepared, feasibility study elaborated and the project prepared of the exploitation system GTW "Geoterma" (Fig. 4.)
- The system "Geoterma" was built and activated as an exploitation-distribution system; the basic "Geoterma" technical-technological parts are:
- Exploitation wells for geothermal water (GTW)
- Pipeline
- Pumping and distributing unit
- Distribution pipeline for GTW

At this phase of development, the system has installed capacity of 300 l/sec, and practically an annual average of 1.400.000 m³ GTW pumped and distributed with mean temperature of 75°C.

The main usage of the geothermal water is for the needs of:

- agricultural production in greenhouses, around 18 ha
- low-temperature technological processes
- Central heating of public and administrative buildings in the downtown Kochani

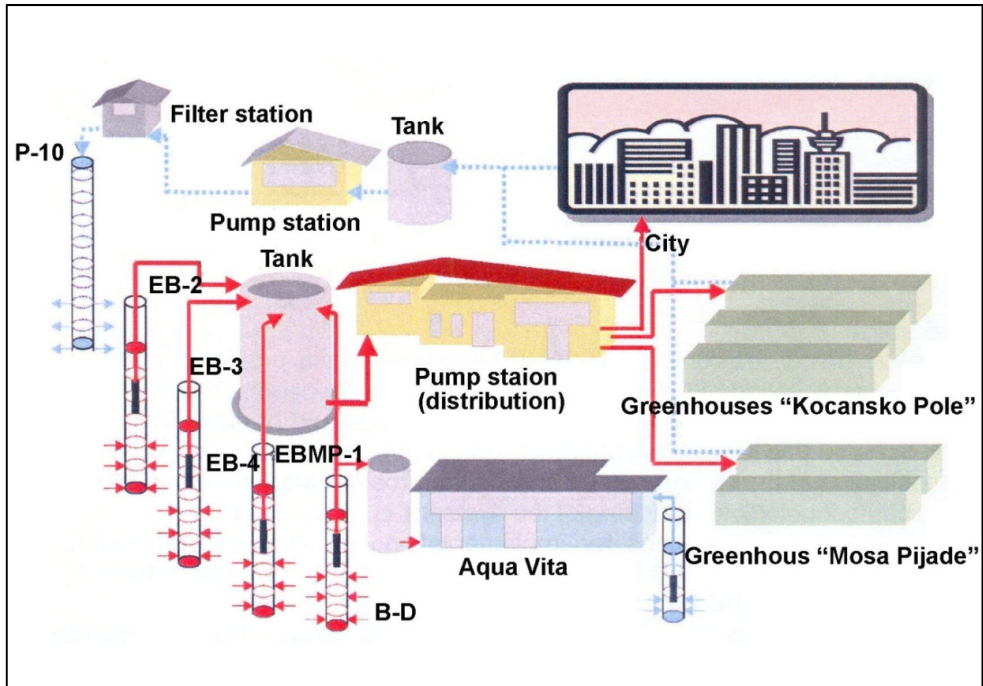


Fig. 4. General scheme of the System for exploitation, distribution and reinjection "Geoterma" – Kochani (Naunov, 2003)

Partial realization of the investment-technical conception of the "Geoterma" system as well as the findings and the results gained during the exploitation phase in the period of 1985-89 with registration of the piezometric level of the basin, clearly and without doubts has shown an urgent need of building of the re-injecting phase of the system (Fig. 5).

For this purpose a ^3H -tritium traced detailed explorative researches have been done and at the same time the unlimited possibility of applying of the re-injection was proven. Afterwards, upon these results and the created project solutions, the basic part of the re-injecting system was realized as an inseparable i.e. complementary part of the whole exploitation system and practically encircled the system "Geoterma".

The re-injection system in this stage of equipment has the main role to cap the used quantities of GTW from the agro complexes (at this stage only from AC "Mosa Pijade"-Podlog) and through the re-injection pump system to inject it back in the re-injection borehole P-10 in the village of Banja. But, besides the big expectations from this re-injecting system, from well known reasons-transformation of 2-valence Fe in to 3-valence Fe in the GTW and creation of voluminous sediment threatening to close the re-injecting borehole-it didn't work well with full capacity.

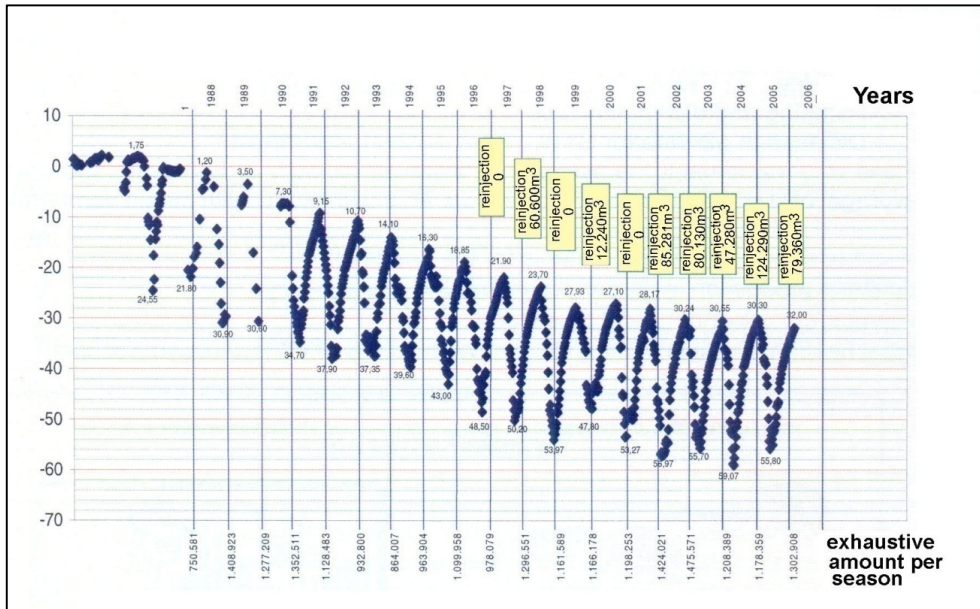


Fig. 5. Chart of the piezometric level of the basin in the period from 01.01.1987 -19.10.2006

4.1.3 Third stage

This stage of the activities: 1995-2003, treats mainly the problems that originated from our experience in exploitation of GTW, as well as problems with development program for the system "Geoterma". Organized as it is with very few innovations and participation of renowned experts and institutions on this field, in this stage we should emphasize the following activities:

- intensification of the researches for solving the problem with the re-injecting system;
- technical-technological equipping of the system;
- researches and preparations for implementation, and the implementation of the project-bottling of GTW;
- encircling of the central heating system for the town of Kochani
- continuity in the research activities for defining the mechanisms of supplementation of the deposit, and completely defining of the one (shown at the prognostic pattern, (Fig. 6);

The other effects are clearly expressed in few segments, above all in using the GTW for bottling, with accent on its outstanding quality and the special wellness characteristics positive for the health of the consumers, as well as for balneology-recreation purposes;

In the scientific-research segment it is a special contribution as applied explorative model and its results;

In the administrative-legislative segment - also as an avant-garde object-project, that helped the development of geothermal science and utilization of geothermal waters in Macedonia.

4.2 Hydro geothermal system Istibanja-Vinica

The hydro geothermal system Istibanja-Vinica, with its thermo-mineral springs is directly settled in the immediate surroundings of the village Istibanja (Vinica), along the flow of river Bregalnica (Fig. 7).

The geothermal field Istibanja - Vinica from geological point of view lies on the contact between two tectonic units (the Serbian-Macedonian massif on the East and the Vardar zone on the West) at the eastern periphery of the Kochani valley, very close to Istibanja and Vinica. The microlocation of the exploitation wells 1-3,1-4 and 1-5 is between the regional motorway Kochani-Istibanja-Delchevo and the river Bregalnica, drilled in the river terrace along the river bed.

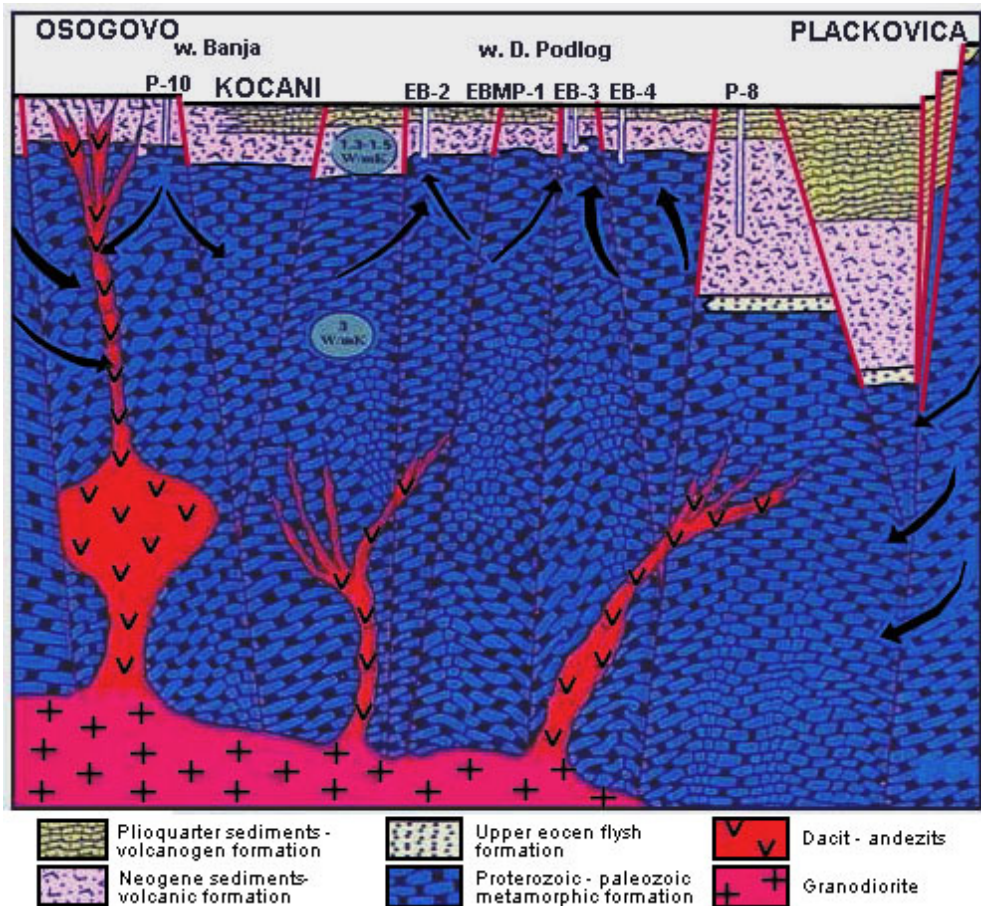


Fig. 6. Forecasted geological model of the geothermal system of the Kochani valley (Naunov, 2003)



Fig. 7. Geothermal field Istibanja-Vinica

As separated hydro geothermal system from the Kochani geothermal field (Podlog-Banja system) is micro-located on a terrain with rocky masses as part of the Serbian-Macedonian geotectonic unit.

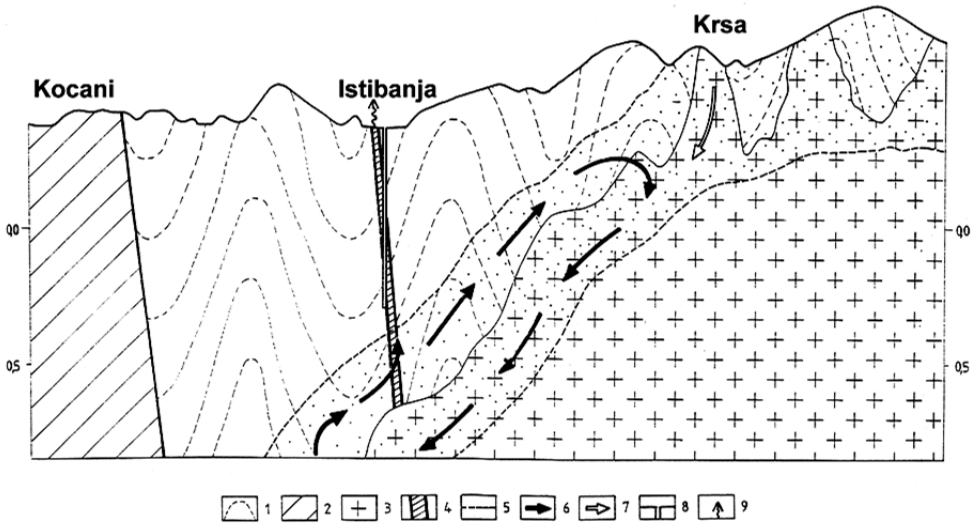
The Serbian-Macedonian massif in the area of Istibanja and Vinica is built up of old Precambrian and Riphean - Cambrian rocks. The former, Precambrian rocks are presented by double-mica striped gneisses (Gmb), a variant of micaschists and amphibolites (Kovacevic et al 1973; .Rakicevik et al, 1973).

While analyzing the neotectonic fault zone (shear) structures, gathered as information from the satellite recordings and the geotectonic map of the RM (Arsovski , 1987) in proportional ratio 1:200.000, we can clearly match the difference between the Vardar zone on one side (western part) and the Serbian-Macedonian massif on the other (eastern part). Many ring like structures with different dimensions are typical for both systems in this region (Podlog, Banja and Istibanja). The neotectonic structural forms in the Serbian-Macedonian massif, where the Istibanja hydro geothermal system belongs are different than the tectonic structures in the Vardar zone. Also, it should be mentioned that the Vardar zone belt has deep shear structures with pretty much expressed seismic activity, contrary to the relatively stable Serbian-Macedonian massif.

The deposit-reservoir of the hydro geothermal system in the geothermal field of Istibanja-Vinica is composed of ruptured Paleozoic gneisses and granites, as shown at the prognostic model on the figure. The supplementation zone for this system is formed by the gneisses,

micaschists and schist's from the Golak downhill- Krshla in the eastern part of the valley as well as from the north-eastern parts of Osogovo Mountains (Fig. 8).

The outflow zone of the system is presented with contemporary geo-thermal occurrences as natural springs in the very surrounding of Istibanja and the exploitation wells I-3, I-4 and I-5 in the very surrounding of the river Bregalnica, to the south of the village Istibanja, Vinica. According to the type of hydro-geo-thermal system, it is found in the group of semi-closed systems in ruptured (jointed) gneisses and granites from the Paleozoic age where the outflow zones are located in the shears.



1.Pt-gneisses, 2. Pz-shall, 3. granite, 4. fault zone, 5. boundary of the reservoir hydrogeothermal, 6. superior direction of movement of thermal water, 7. superior direction of movement of cold water, 8. constructed boreholes, 9. thermal source.

Fig. 8. Forecast model of the geo-thermal field Istibanja – Vinica

The GTW from this hydro geothermal system is used in the greenhouse complex (6 ha), that is warmed using combination of geothermal water and crude oil. Supported by the grants from the Austrian government in the period after the year 2000, the system was reconstructed and prepared for production and export. The geothermal system Istibanja is using geothermal water from three exploitation wells with total capacity of 56 l/sec and water temperature of 67°C, connected with pipelines long 3,25 km. The actual available capacity that reaches the greenhouses (agricultural complex) is 50 l/sec with water temperatures of 61 °C.

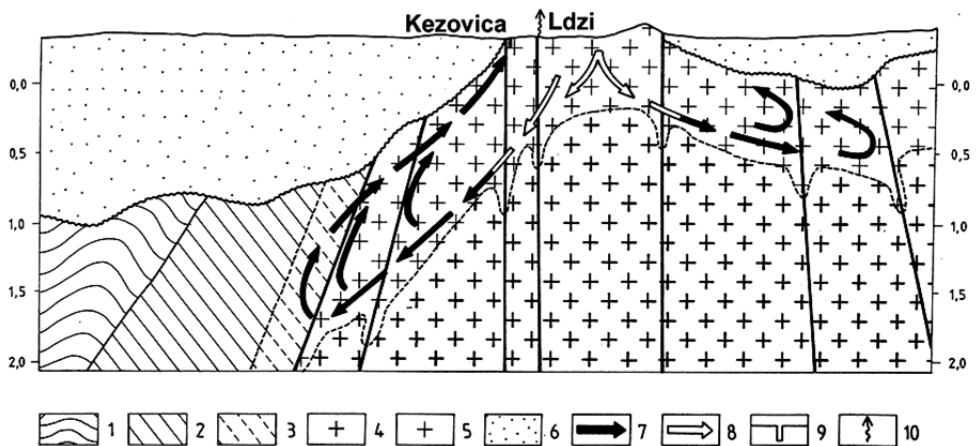
4.3 Hydro geothermal system Kezhovica - Shtip

On the right shore of river Bregalnica, approximately 2 km to the southwest from the center of Shtip, on the exit of Novo Selo, lays the geothermal system Kezhovica - Ldzhi (Fig. 9).



Fig. 9. Geothermal spring Ldži, near Shtip

Hydro geothermal system Kezhovica - Ldži is near of Kezhovica spa at Novo Selo - Shtip. The reservoir of this hydro-geo-thermal system is built on Jurassic joint granites (Fig. 10). Big part of these granites is covered with tertiary sediments of Ovchepole and Lakavichki basin (Fig. 11).



1. shall, 2. gneisses, 3. reservoir of gneisses, 4. massive granite, 5. cracked granite, 6. tertiary sediments, 7. superior direction of movement of thermal water, 8. superior direction of movement of cold water, 9. constructed boreholes, 10. thermal source.

Fig. 10. Forecasted model of the Kezhovica - Ldži geothermal system

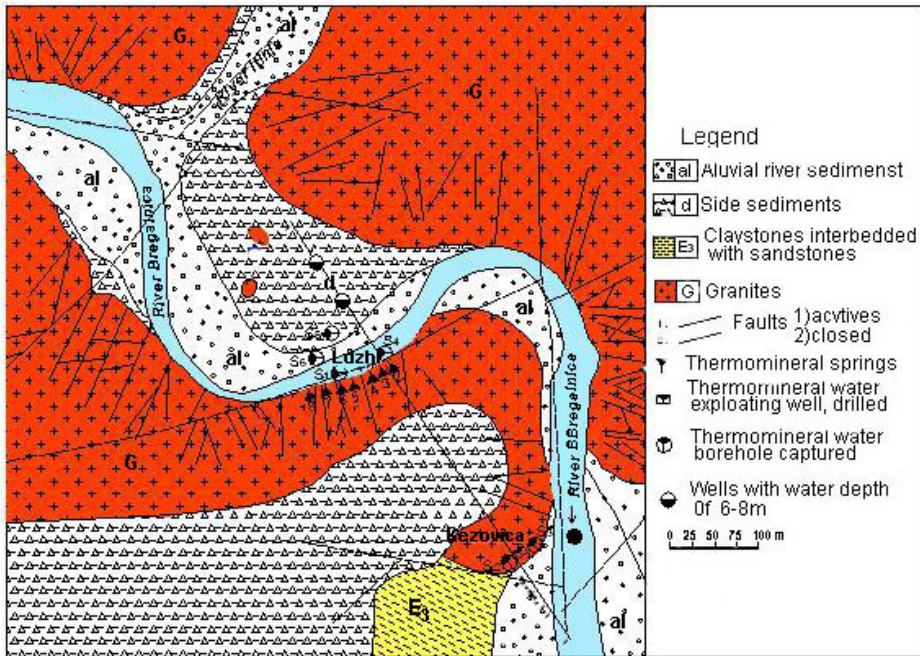


Fig. 11. Geological map of the hydro geothermal system of Kezovica Spa

Kezhovica spa today uses water from two shallow wells with capacity of 4,5 l/sec with temperature of 63°C. The supplementation of the system comes from the granite, south from Shtip. The chemic ingredient of the water shows supplementation also from the filch sediments Ovche Pole. According to the type, this system belongs to the half opened hydro geothermal systems. With chemical analysis of the water in this system is from Na-Cl type (Alekin,1953), and the calculate geothermometers are applying that the forecasted temperature of the tank is 100 - 115 °C.

The site of these geothermal waters is located between the hills Isar and Kumlako from the left and Marite from the right side of the river Bregalnica. In Kezovica, 30 years ago there w only one drilled well which was used as capping in the old Shtip spa, and by the Ldzhi, as nc capped thermo mineral water leaking in few places directly on the surface. With the research made in 1953 and with information gained, on the location of the old spa in the next few years new spa has been built, with modern areas and pools and also modern rehabilitation center has been built. Kezhovica as a spa is known since the Ottoman's Empire in Macedonia, when it was used as healing thermal water, too.

Contrary to Kezhovica, the locality Ldzhi, except the relatively shallow researched drills E the formed pipelines around these drills, until these days nothing more has been done researching of this hydro geothermal system (Kekic and Mitev, 1976).

Kezhovica Spa and the thermo-mineral system Ldzhi, although are well known as import hydro geothermal phenomena especially with their great radioactivity and healing characteristic for their exploration and valorization of their geothermal fluid, nothing particular

has been do Thermo-mineral waters in Kezhovica Spa are not overflowing, but today they are used by shallow wells with capacity of 4,5 l/s and water temperature of 57 - 63°C.

In Ldzhi locality there are more thermo-mineral waters in form of springs. Their maxi capacity is minimal and around 0,03-1,0 l/s. Captivated spring that exists today is with capacity 0,5-1,0 l/s. All these springs are with the same origin and are hydraulically connected, and t temperature varies from 28 - 59°C. The water in Ldzhi Spa has variable maximal capacity depends on the water in the river Bregalnica. It has the characteristic that with the raising of level of the water in the river Bregalnica, beside the capacity of the thermo-mineral water in L springs, there is uprising of the temperature of this water. That is explained with deep infiltrate of the river flow underground this terrain, through existing joints where the same has capability, besides the emerging of the capacity of the thermo-mineral water, to heat to a hi | temperature.

According to the results from ht chemical analysis of the thermo-mineral water in Kezhovica Spa and Ldzhi springs, it can be said that they are CI - Na waters. Total mineralization of the water in the capping of Kezhovica Spa is 1450 mg/l, and at Ldzhi springs varies from 1310,4 -1507,9 mg/l. Kezhovica Spa by its radioactivity belongs to one of the most radioactive thermo-mineral waters not only in Macedonia, but also in the wider region. The radioactivity in the capping Kezhovica is 42,82 Mach units, and the water in Ldzhi springs is 11,57 Mach units. This bigger radioactivity of the water in Kezhovica Spa related to the radioactivity of the water from Ldzhi springs, should be taken in consideration of the tectonic or seismic-tectonic activity of the main stratum that passes near Kezhovica, which is the main seismic dislocation that spreads from Strumica on the South through Kezhovica and Sveti Nikole all the way to Kumanovo (Kotevski, 1977).

During the years 1953 and 1964, there were six shallow explorative holes drilled (C-1 to C-6), and a large one (D-7). Their maximal capacity in terms of exploitation done in that period was 20 l/s. During the year 1983, nearby Ldzhi springs, on the right side of river Bregalnica, there was another research hole drilled, B-4 with maximum capacity of 30 l/s and with the temperature of the water 32°C. The temperature now is lowered because the water is a mixture of the surface Bregalnica water and hot water from the deep springs of cracked granites which are the tank (reservoirs) of this geothermal system, nearby Shtip.

The healing power of the water from Kezhovica Spa is in its high temperature, radioactivity and the chemical structure.

Total amount of the balanced reserves of the hydro geothermal system Kezhovica-Ldzhi are shown on Table 2.

| Well number | Location | Capacity Q (l/s) | Water temperature t(°C) |
|------------------------|------------------------------|------------------|-------------------------|
| S - 53 g. | Kezhovica Spa | 2,7 | 62 |
| B - 1/76 | Kezhovica Spa | 1,3 | 58 |
| Total (1) | Kezhovica Spa | 4,0 | 58 - 62°C |
| Well B - 2/97 | Ldzhi | 11,5 | 53 |
| Well B - 3/97 | Ldzhi | 6,5 | 60 |
| Total (2) | Ldzhi | 17,5 | 53 - 60°C |
| Total (1) + (2) | Kezhovica Spa + Ldzhi | 21,5 | 53 - 62°C |

Table 2. Balance reserves of the Kozovica-Ldzhi systems

5. Utilization of the geothermal energy in the spa complexes

Macedonia although a small country is very rich in thermal and thermo-mineral water, that are currently used in the thermal spas and medical recreation centers. The geothermal energy of these geothermal and thermo-mineral waters is used in eight thermal spas, and four are located in the eastern and southeastern part of Macedonia. The thermo-mineral water in these complexes has various physical-chemical characteristics and temperatures, depending on the site and localization of the geothermal field where the spa complex is located. The water temperatures in the spas in Macedonia, starting with the highest are: Spa Bansko - 73°C, Kezhovica Spa - 54°C, Spa Negorci 38°C etc. With regards to the quantities of available flow of geothermal water in the spas in eastern and southeastern Macedonia: in Spa Bansko - 35 l/s, Kezhovica Spa - 5,4 l/s, Spa Negorci 1,8 l/s, etc. The utilization of the geothermal energy in the spa complexes in eastern and southeastern Macedonia and their thermal power are presented in Table 3.

| Nr. | Location | Flow Q (kg/s) | Temp. (°C) | Thermal power for this temp. ¹ 15°C (MW _t) | Annual usage ² (TJ/year) |
|-----|---------------|---------------|------------|---|-------------------------------------|
| 1 | Spa Bansko | 35 | 70 | 8,05 | 253,9 |
| 2 | Kezhovica Spa | 5,4 | 54 | 0,88 | 27,7 |
| 3 | Negorci Spa | 1,8 | 38 | 0,17 | 5,46 |
| 4 | Kocani Spa | 30 | 63 | 6,02 | 189,9 |
| I | TOTAL | 72,2 | | 15,12 | 476,96 |

¹) Thermal power (MW_t) = Max flow Q (kg/s) h inflow T(°C) - outflow T(°C) × 0,004184 (MW=10⁶W)

²) Annual usage (TJ/year) = Average spend Q (kg/I) × inflow T(°C) - outflow T(°C) × 0,1319 (TJ/year)

Table 3. The utilization of the geothermal energy in the spa complexes in eastern and southeastern Macedonia and their thermal power

The planned reconstructions of the heating installations that use the geothermal water in the spa and recreational complexes in eastern and south-eastern Macedonia are still not implemented because of unsolved property issues. However, one can't expect positive developments unless the ownership over the public spa complexes is defined.

6. Comparison of the geothermal potential resources with the other sources of energy and the geothermal

In order to analyze the economic aspects of the exploitation of the geothermal energy as a power source, a unique and adequate access towards forming of the prices of every separate kind of energy source is needed, which are produced and distributed from the energetic systems, as well as for the market price of the oil at the moment when the analysis are being done. Macedonia is a part of the group of developing countries. After the independence in 1991, it entered the period of "transition" and change of the capital from public into private that also influenced the sector of industrial production and energy.

Macedonia as main power source is using domestic coal and hydro energy from power plants and imported oil. The utilization of the solar energy is insignificantly small related to the needs and the possibilities, and the utilization of the natural gas is still in a phase of preparation, but also it's imported. The energy from the biomasses is still in experimental phase.

The coal is the best researched power source in Macedonia. Total deposits of coal are 906.247×10^3 t.

The hydro power of the rivers in Macedonia is still not used enough and currently it's exploited in a thermal equivalent of 411 MW. The needs and the participation of every single power source in the energy balance of Macedonia is presented in Table 4.

| Type of power sources | Annual consumption (TJ) | Part in the whole consumption (%) |
|-----------------------|-------------------------|-----------------------------------|
| Coal | 59.700 | 56,13 |
| Woods | 10.097 | 9,49 |
| Liquids | 33.044 | 31,07 |
| Renewable | 500 | 0,47 |
| Hydropower | 2.498 | 2,35 |
| <i>Geothermal</i> | 510 | 0,48 |
| Total | 106.347 | 100 |

Table 4. The needs and the participation of every single power source in the energy balance of Macedonia

7. Hydrochemical analysis of tested water

In the recent period, from geochemical point of view, the best studied are thermo - mineral waters from the springs Ldзи and Kezovica. Further will be presented the hydrochemical characteristics of mentioned system.

Analyses of the chemical composition of the thermo - mineral waters, done on the samples from the exploited well in the spa and the springs Ldзи, showed that in both cases waters are of chloride - sodium, for the springs Ldзи of first type, and for the spa Kezovica of second type.

Total mineralization of the water from the spa Kezovica is 1450.0 mg/l, and from the springs Ldзи varies within 1310.4 to 1507.9 mg/l in the main spring, where in 1953 was drilled the borehole C-4. pH value of this spring and the spa Kezovica is 7.2, based on the examinations of "Industroproject" Zagreb this value is 7.6 for Kezovica and 7.8 for Ldзи Table 5. It is obvious that these waters are on the border between the neutral and alkaline.

About the hardness of the waters from these localities, the general hardness for the gathering on Kezovica is 8.5 dH°, and the carbonate is 9.0 dH°. For the springs Ldзи, the general hardness is 5.9 dH°, and the carbonate is within 7.7 to 9.6 dH°. The largest hardness in the springs Ldзи is in the spring No. 7 where the total mineralization is the smallest. Also, this spring has the lowest temperature (30° C). Probably, it is because of mixing of the thermo - mineral waters with the water from the river Bregalnica, which could be seen on the terrain.

Analyses made from "Industroproject" Zagreb showed increased general hardness - For Kezovica 10 dH°, and for the springs Ldзи 14 dH°.

It should be said that there is no magnesium in the springs Ldзи, and in the gathered waters of the spa Kezovica, the amount of magnesium is 33.0 mg/l and according "Industroproject" Zagreb is 35 mg/l. the question arises why this is present when both waters appeared in the

| ANIONS mg/l | | | | | | | | | | CATIONS mg/l | | | | | | |
|--------------------------------|------------------|-------------------------------|--------------------------------|------------------------------|-------------------------------|-------------------------------|--|---------------------|------------------|------------------|-----------------|----------------------|---|-------|----|----|
| SO ₄ ²⁻ | Cl ⁻ | HCO ₃ ⁻ | NO ₃ ⁻ | NO ₂ ⁻ | CO ₃ ²⁻ | HBO ₃ ⁻ | H ₂ AsO ₄ ⁻ | SUM | Ca ⁺⁺ | Mg ⁺⁺ | Na ⁺ | K ⁺ | Fe ⁺⁺ | SUM | | |
| 145.0 | 492.0 | 166.0 | - | - | 14.0 | 120.0 | 1.0 | 938.0 | 10.0 | 35.0 | 448.0 | 12.5 | 1.0 | 506.5 | | |
| ELEMENTS IN | | | | | | | | | | | | | | | | |
| COLOIDAL SOLVED OXIDES mg/l | | | | | SOLVED GASES mg/l | | | | | ELEMENTS IN | | | | | | |
| Fe ₂ O ₃ | MnO ₂ | SiO ₂ | Al ₂ O ₃ | SUM | CO ₂ | H ₂ S | NH ₄ | SO ₂ | Cl ₂ | O ₂ | SUM | Li | Cs | Br | As | Hg |
| - | 0.20 | 3.0 | 0.04 | 3.24 | - | - | 0.04 | - | - | 4.0 | 4.04 | 0.20 | 0.12 | - | - | - |
| ELEMENTS IN | | | | | | | | | | | | | | | | |
| TRACES mg/l | | | | | Total mineral, (mg/l) | Dry residue (mg/l) | Lost of ignition (mg/l) | Total hardness (dH) | pH | Eh | t (°C) | Radio-activity (Mah) | Curl's formula | | | |
| Rb | F | J | Sb | Pb | 1445.0 | 1400.0 | 1350.0 | 10.0 | 7.6 | +210 | 57 | 11.57 | Cl ₅₈ HbO _{3.7} SO _{4.8} HCO _{3.11} Ml.4-----t57 ⁰ Na ₈₄ Mg ₁₂ | | | |
| 0.15 | 2.5 | - | 0.002 | 0.001 | | | | | | | | | | | | |

Table 5. Chemical analysis of thermo - mineral waters from spa Kezovica ("Industroproject" - Zagreb)

granites on the fault lines. It should be bearing in mind that thermo- mineral waters Kezovica are on the fault line between granites and Upper Eocene sediments and the springs Ldzi occurred in granites. Magnesium is always present in the sediments which is concluded and from the chemical analyses of the springs with cold water Ribnik (79.2 mg/l magnesium) and Krstot (28.8 mg/l magnesium) Table 6. Also, chemical analyses from Novo Selo showed presence of this element in range of 15.1 - 40.3 mg/l, which means that underground waters from the sediments contain magnesium unlike the waters from the granites.

7.1 Radioactivity

Based on the radioactivity, thermo - mineral waters in the vicinity of Shtip are different, although they are placed in the same rock masses and on the fault lines which through the transverse faults and the tectonic cracks communicate with each other. Based on the analyses of S. Miholik, radioactivity of the waters from the gathering of the waters in Kezovica is 42.82 Mache units (ME), and from Ldzi is 11.57 ME. Based on this, the spa Kezovica is one of the most radioactive spas in Europe.

The increased radioactivity of the water in Kezovica related to that from the spring Ldzi is because of the tectonic, i. e. seismo - tectonic activity of the main fault passing by the Kezovica. This fault is principal seismic dislocation that extends from Strumica, through Kezovica and Sveti Nikole to Kumanovo.

From this arises that with analysis of the radioactivity of dipper underground waters that followed the fault lines could help in exploration of contemporary seismic activity of this terrain.

8. Geological exploration and exploitation of mineral raw materials

Thermal mineral waters by their nature are classified in the group of energy mineral raw materials and are goods of common interest for Macedonia.

According to the Law on Mineral Raw Materials (OGORM no.18/99 and 29/02), a DGE aimed at finding, identifying deposits of thermal mineral water, as well as evaluating their economic effects is conducted by means of a concession.

The Law on Mineral Raw Materials regulates the conditions and the manner of conducting geological explorations, as well as the conditions for exploitation of mineral raw materials situated in the ground or on its surface, concessions for geological research and concessions for exploitation of mineral raw materials, the realization, the maintenance and the utilization of geothermal waters, work safety measures, environmental protection during the exploration and the exploitation of the given area and the geological measurements and plans.

The concession for conducting DGE is issued by the Government of the Republic of Macedonia. The Ministry of Economy, as the competent body responsible for coordination of the procedures for conducting DGE, undertakes inter-sectoral consultations with the state administration bodies with regards to the application for the concession, and primarily with the body responsible for environmental protection and water protection.

Mutual rights and obligations of the Government of the Republic of Macedonia and the concessionaire are regulated with a Concession Contract.

| No. | Cadastral num. | Type and location of the object | Water temp. (°C) | pH | CATIONS (mg/l) | | | | | | | ANIONS (mg/l) | | | | | Dry residue on 110°C (mg/l) | General hardness (°dH) | Carbonate hardness (°dH) | Class, Group and type of water according Alskin | | | |
|-----|----------------|---------------------------------|------------------|-----|------------------|------------------|-----------------------|-----------|------------------------------|-----------------|-------------------------------|------------------------------|------------------------------|------------------------------|------------------|--------------------------------|-----------------------------|------------------------|--------------------------|---|-----------|------|--|
| | | | | | Ca ⁺⁺ | Mg ⁺⁺ | Na+K+Fe ⁺⁺ | Σk (mg/l) | SO ₄ ⁻ | Cl ⁻ | HCO ₃ ⁻ | CO ₃ ⁻ | NO ₃ ⁻ | NO ₂ ⁻ | SiO ₂ | Al ₂ O ₃ | | | | | ΣA (mg/l) | | |
| 1 | 1 | Drilled well spa "Kezovica" | 58 | 7.2 | 15.1 | 33.0 | 483.3 | 0.15 | 467.5 | 162.4 | 511.2 | 195.2 | 15.5 | - | - | 75.0 | 1.2 | 886.3 | 1450.0 | 1419.2 | 8.5 | 9.0 | Chloride, sodium, second type |
| 2 | 2 | Thermal well Novo Selo - Ldži | 55 | 7.2 | 18.2 | - | 483.3 | 0.02 | 571.5 | 164.4 | 538.0 | 169.0 | 12.0 | Trace | - | 62.0 | 1.0 | 883.4 | 1507.9 | 1480.8 | 2.5 | 8.4 | Chloride, sodium, first type |
| 3 | 3 | - II - | 48 | 7.0 | 18.2 | - | 475.3 | 0.06 | 563.5 | 130.3 | 545.8 | 195.2 | 3.0 | - | - | - | - | 874.3 | 1437.8 | - | 2.6 | 9.0 | Chloride, sodium, first type |
| 4 | 4 | - II - | 41 | 7.0 | 15.1 | - | 481.7 | 0.02 | 496.8 | 164.8 | 539.6 | 164.8 | 6.0 | - | - | - | - | 875.2 | 1372.0 | - | 2.2 | 8.1 | Chloride, sodium, first type |
| 5 | 5 | - II - | 47 | 7.0 | 18.1 | - | 467.8 | 0.06 | 532.9 | 158.2 | 525.4 | 172.0 | 4.5 | - | - | - | - | 860.1 | 1400.0 | - | 2.6 | 8.1 | Chloride, sodium, first type |
| 6 | 6 | - II - | 43 | 7.0 | 18.1 | - | 482.9 | 0.26 | 501.2 | 179.5 | 543.2 | 156.7 | 6.2 | - | - | - | - | 885.6 | 1386.8 | - | 2.6 | 7.7 | Chloride, sodium, first type |
| 7 | 7 | - II - | 30 | 7.0 | 28.4 | 3.6 | 455.9 | 0.06 | 487.9 | 165.5 | 546.4 | 206.4 | 4.2 | - | - | - | - | 822.5 | 1310.4 | - | 5.9 | 9.6 | Chloride, sodium, first type |
| 8 | 12 | Digged well Novo Selo | 13 | 7.2 | 102.8 | 40.3 | 46.7 | 0.02 | 189.8 | 70.5 | 67.4 | 414.8 | - | - | - | - | - | 552.7 | 742.5 | - | 23.8 | 19.0 | Hydrocarbonate, calcium, third type |
| 9 | 9 | - II - | 15 | 7.2 | 21.1 | 15.1 | 56.5 | 0.02 | 92.7 | 42.6 | 33.7 | 335.5 | - | - | - | - | - | 411.8 | 504.5 | - | 15.1 | 15.4 | Hydrocarbonate, calcium, first type |
| 10 | 10 | - II - | 14 | 7.2 | 84.8 | 32.4 | 77.7 | 0.02 | 194.9 | 73.8 | 61.1 | 384.3 | - | - | - | - | - | 518.2 | 713.1 | - | 19.6 | 17.6 | Hydrocarbonate, calcium, third type |
| 11 | 13 | Spring Ribnik | 14 | 7.0 | 64.0 | 79.2 | 59.1 | 0.02 | 202.3 | 106.6 | 19.9 | 579.5 | - | - | - | - | - | 705.0 | 907.3 | - | 27.5 | 26.6 | Hydrocarbonate, magnesium, second type |
| 12 | 15 | Spring Krstot | 18 | 7.4 | 32.4 | 28.8 | 105.7 | 0.13 | 167.0 | 47.5 | 21.3 | 427.0 | - | - | - | - | - | 495.8 | 662.8 | - | 11.2 | 19.6 | Hydrocarbonate, calcium, first type |

Table 6. Chemical analysis of the underground waters – spa "Kezovica" and the wider vicinity

Concession for DGE is issued by the Government of the Republic of Macedonia based on a public tender and based on the application/offer submitted by an interested legal entity or natural person. In instances when there are no interested subjects for the public tender, the concession may also be granted based on an offer, which is submitted to the Ministry of Economy.

The applications for issuing a concession is accompanied by a topographic map with a scale of 1:25.000 or 1:50.000 with drawn boundaries of the area where DGE will be conducted or where the exploitation of mineral raw materials will be carried out, as well as a proof of the right to use the results of the DGE, if there have been other prior DGE conducted in the same area

The application for issuing a concession for DGE includes in particular:

- data of the applicant
- type of mineral raw material
- location where that particular mineral raw material is found, in this case geothermal water
- technical and technological explanation for the need to conduct DGE
- Certificate from the Ministry of Finance - Public Revenue Office stating that the applicant has paid all its taxes
- Certificate from the competent Court stating that applicant is not subject to a bankruptcy procedure.

If the area for which a concession for DGE or exploitation of mineral raw materials is being issued, is partially or completely state owned, the Government of the Republic of Macedonia at the request of the concessionaire will grant the use of that land.

A concession for DGE and for exploitation of mineral raw materials can be issued to a domestic or foreign legal entity or natural person (concessionaire) under the conditions stipulated by this Law and the Law on Concessions.

Before the approval of the concession for DGE, the Ministry of Economy will request an opinion from the competent body for environmental protection and protection of nature, the competent body for water protection, as well as other competent bodies.

The legal entity or natural person which has acquired the concession for conducting DGE automatically gains the right to receive a concession for exploitation of mineral raw materials, if the conditions for exploitation of mineral raw materials provided by this Law are fulfilled.

This right is acquired by submitting an application for receiving a concession for exploitation of mineral raw materials at least 6 months prior to the expiration of the concession for DGE.

The concession for DGE is granted for a particular location and for maximum period of 8 years, without a possibility for extension. The location for DGE or exploitation of underground waters or thermal mineral waters can not exceed 2,0 km².

The results obtained from the DGE under the terms of a concession are property of the concessionaire and can be sold for an adequate compensation.

Concessions for exploitation of mineral raw materials can be granted for a period of maximum 30 years with a possibility for extension of another 30 years, by signing a new Concession Contract. The application for extension of the concession is submitted at least 3 months prior the expiration of the period for which the concession is granted.

The concession for DGE and exploitation of mineral raw materials can be transferred to another party with the consent from the Government of the Republic of Macedonia. The amount for the concession is determined with the Concession Contract, which is adopted by the Government of the Republic of Macedonia based on a proposal from the Ministry of Economy.

9. Conditions for conducting DGE

Detailed geological explorations (DGE) can be conducted by a domestic or foreign legal entity or natural person, registered for performing the given activity, which fulfils the conditions prescribed by the Law on Mineral Raw Materials and other related laws. During the DGE, all measures for occupational safety and environmental protection must be provided and undertaken. Eventual damages made during the DGE are compensated according to indemnity regulations. DGE and exploitation of mineral raw materials can be conducted on a land or facilities which are public property, and in other areas which are protected by the Law only with a prior approval from a competent body.

DGE is initiated on a defined location based on a previously granted concession and approval for DGE.

The location for the DGE is a part of a terrain circumfered by dots, connected with straight lines and is spreading out to unlimited depth underground between the virtual planes which pass through those lines or natural boundaries which are recorded on the topographic maps, in an appropriate scale.

DGE of mineral raw materials are explorations which provide: detailed information for the hydrogeology of the terrain, the location, the capacity and genesis of the deposit of raw materials, the available deposits of raw materials and the exploitation possibilities accompanied by an assessment of the economic benefit.

The concessionaire has to obtain an Approval for conducting DGE from a competent body in order to start with the on-site works.

10. Approval for conducting detailed geological explorations (DGE)

Approval for conducting DGE is issued on the base of the application submitted by the legal entity or natural person. With the application for issuing of an Approval for DGE the following documents are submitted: Concession contract, Program for DGE, topographic map with the actual border lines of the research area in adequate scale.

The Approval for DGE contains:

- Information about the legal entity or natural person to whom the approval is issued.
- Mineral raw materials which are subject of the DGE
- The area of the DGE with specific coordinates
- The type and scope of the activities that should be performed
- The deadline to start with the exploratory work and
- The duration of the DGE and the deadline for the submission of a performance report on the DGE.
- The holder of the Approval can not start with the DGE, unless he has resolved all property and legal issues for the area defined in the Approval for DGE.
- Approval for DGE is issued within 60 days from the day when the application was submitted.

Against the decision with which the application for the approval is rejected, a complaint can be submitted within 15 days from the day of its receipt, to the Committee for resolving administrative procedures of the second instance in the area of economy of the Government of the RM.

The Ministry of Economy can revoke the Approval from Article 33 of this Law, if the legal entity or natural person which is conducting the DGE doesn't start within the determined deadline or if the explorations have been stopped for more than 3 years, unless the reasons for this stoppage were of technical or economic nature, or if the holder of the Approval is not responsible for the reasons for stopping (*vis major*).

After the stopping or completion of the DGE it's obligatory to file a report to the Ministry of Economy, i.e. an Elaborate for the conducted explorations is being prepared, with complete documentation of the results. The results obtained with the DGE are property of the concessionaire and can be alienated for an appropriate compensation.

11. Exploration of geothermal waters

According to the Law on Mineral Raw Materials which also includes geothermal waters, exploitation of mineral raw materials is an act of obtaining, or releasing mineral raw materials from their natural state (*in situ*), including the preparatory, accompanying and consequent activities related to the exploitation of mineral raw materials. Exploitation of geothermal waters is carried out in a specifically defined space, determined in accordance with the DGE report. The area for the DGE or exploitation of underground waters or geothermal water is maximum 2 km².

The right of exploitation of mineral raw materials, which include geothermal waters, is obtained through the granting of a concession for exploitation of geothermal waters.

Before the concession for exploiting is issued, the Ministry of Economy, as a the body responsible for coordination of procedures for exploitation of mineral raw materials, conducts inter-sectoral consultations with other state administration bodies regarding the application for the issuance of a concession, and primarily with the competent body for protection of the environment, waters, forests and cultural heritage, as well as the competent body for transport infrastructure.

The concession for conducting exploitation is granted by the Government of the Republic of Macedonia. The period for which the concession is granted is limited by law to 30 years. The mutual rights and obligations of the Government of the Republic of Macedonia and the concessionaire are regulated with the concession contract.

The issuance of concessions for exploitation of geothermal waters, as well as for other mineral raw materials in accordance with the Law on Mineral Raw Materials (OGORM no. 19/99 and 29/02) is performed by the Government of R.M based on a public competition or on application/offer of an interested legal entity or natural person.

The application for granting a concession for exploitation of geothermal waters as well as for other mineral raw materials should contain:

- data of the applicant
- proof of the right to use the results of the conducted DGE
- type of mineral raw materials
- location where the mineral raw material is identified, or in this case the geothermal water
- topographic map on a scale of 1:25.000 or 1:50.000 with coordinates of the border lines of the location
- technical and technological explanation of the exploitation of geothermal waters
- Certificate from the Ministry of Finance - Public Revenue Office of paid public taxes by the applicant
- Certificate from the competent Court certificate stating that the applicant is not subject to a bankruptcy procedure and
- Certificate from the competent Court that no bans for performing activities has been issued against the applicant

The exploitation of the geothermal waters can start after the approval for exploration is given to the applicant.

This approval is issued by the Ministry of Economy. For the purpose of granting of the approval for exploitation, the applicant should submit the following:

- Concession contract for exploitation of mineral raw materials.
- Main project for exploitation of mineral raw materials and the deposit, with an expert assessment (review).
- *Elaborate on the environmental impact assessment.*
- Decision for utilization of constructed facilities foreseen in the main project, successively after their construction.
- Proof of resolved property legal relations (this refers to resolved property legal relations with regards to the micro-location of geothermal exploitation)
- Situational plan with defined borderlines of the area where exploitation of the mineral raw materials will be conducted, to the extent it allows defining the boundaries of the area, as well as defining public and other facilities.
- Transfer of concession for carrying out the exploitation of mineral raw materials (geothermal waters) can be carried out in accordance with the Government of the Republic of Macedonia.

The Ministry of Economy can revoke the Approval for exploitation from Article 63 of the Law on Mineral Raw Materials (according to the Law on Changes and Amendments to the Law on Mineral Raw Materials, OGoRM no. 29/02) if the performer of exploitation of mineral raw materials doesn't start within 3 years of the day of the issuance of the Approval, or if regular exploitation was stopped for more than 3 years, unless the reasons for the stoppage were of technical or economic nature, or if the holder of the Approval was not responsible for the reasons for the stoppage (*vis major*).

Supervision over implementation of the Concession Contract is carried out by the Concedent, i.e. the Ministry of Economy and the State Inspectorate for Technical Inspection through mining and geological inspectors.

The amount of the concession fees is determined with a special Decision for determining the criteria for the amount of the concession fee for conducting DGE and exploitation of mineral raw materials, adopted by the Government of the Republic of Macedonia.

It's important to note that the calculation of the concession fee is done per production unit of produced mineral raw material.

For a complete overview of the administrative procedure for concessions for geological explorations and exploitation of mineral raw materials, including geothermal water, a brief presentation of the required documents and the procedure is provided below.

12. Commentary instead of conclusion about the legislation for issuing concessions for exploiting the geothermal energy in the Republic of Macedonia

Geothermal resources (geothermal waters and their geothermal energy) by their nature are classified in the group of energy mineral raw materials and are goods of common interest of the country, according the Law on Mineral Raw Materials (OGoRM no. 18/99 and 29/02). Detailed geological explorations (DGE) aimed at finding; identifying deposits with thermal mineral water, as well as evaluating their economic effects are conducted through concession. Concession as an institute in legislation entails obtaining a certain right, with or without certain conditions, for a limited or unlimited time. A Concession for DGE, as well as Concession for exploitation of mineral raw materials, can be issued to a domestic and foreign legal entity and natural person (concessionaire) under the conditions defined by the Law on Mineral Raw Materials and Law on Concession. With regards to geothermal energy, the experiences in this area show that two types of concession are characteristic: the right to perform geological explorations in order to identify the energy resource and right to use the resource under specific conditions. Unfortunately, this is where all similarities with mineral raw materials end, because the concessions mostly apply to using hot water or steam, which automatically includes the application of the Law on Waters. Because of the potential negative environmental impact caused by the use of hot water and water with high mineral content, the legal provisions related to environmental protection are applied in conjunction with the Law on Ecology.

This immediately poses the question whether is it possible to harmonize three different legal areas in order to ensure more efficient resolution of the problem, and if this is not possible,

is it necessary to create a special legislation for utilization of geothermal energy, which will define all aspects involved in geological exploration and exploitation of this specific energy resources. Concessions are granted by the Government of the Republic of Macedonia, based on a submitted application.

There is a clear difference in the legislations of European countries regulating the obtaining of licenses for exploration and exploitation of the geothermal resources, as a consequence of the specific development of the legislations in general and the specificities of the geothermal resource themselves. However, the application in practice of certain provisions is common for all European countries, and the Republic of Macedonia should strive and move in this direction, as described below:

Ownership of the energy resource

Geothermal energy resources are owned by the state and can not be alienated. The ownership of the energy resource is in no form related to the ownership of the land under which the resource is located. The former means that the owner of the land has no right to obstruct any investigations or exploitation of the energy resource, regardless of the use of the land, but in the same time means fair compensation for possible damages made in the course of exploration, building the infrastructure or exploitation. The owner of the land is given priority in applying for concession for DGE or exploitation if he offers the same or approximately the same conditions as the most favourable offer, because the concessions are issued through a public tender.

Conducting of exploratory work for identification of the energy resource

The state issues Approval for DGE under strictly defined procedures and conditions only to qualified companies and institutions which have to provide technical documentation and bank guarantees, ensuring its implementation. The role of the state is to control and provide full protection of the energy resource and the environment where the exploration is carried out or to prevent speculations aimed at stopping the activities for activating the energy resource.

Exploitation of the geothermal resource

The state grants the rights for exploitation of the geothermal resource under strictly defined procedures and conditions. The license for exploitation of the energy resource entails full protection of the energy resource from excessive or improper usage. The right to control also means accepting direct responsibility to the holder of the concession i.e. the state can not issue concession for geothermal fields for which it has already issued concessions to specific users.

In the procedure for issuing concessions for exploration and exploitation, it is important to emphasize the system of dual responsibilities i.e. full protection of the rights of the state, but also the rights of the holders of the license for exploration and exploitation of the energy resource. The more they are defined by law in a clear and directly applicable manner, the more their practical application will be efficient.

All these aspects in the development of the legislation regulating the issuance of concessions for exploration and exploitation, and consequently the utilization of the geothermal energy, are mostly applied in various European countries that have a tradition in the utilization of

this specific resource and can provide useful insights for the development of a concrete legislation in the Republic of Macedonia.

The implementation of the current Law on Mineral Raw Materials in practice, as well as the taking of responsibilities as a result of the need for approximation of Macedonian with European legislations, lead to the need to draft a new Law on Mineral Raw Materials. The law proposal was drafted by the Ministry of Economy in collaboration with the German Technical Cooperation (GTZ).

The main characteristic of the new law proposal is that a much clearer systematization of the provisions is applied as compared to the existing one. Also, the proposal for adoption of the Law incorporates Directives which are indirectly transposed in this Law through the Law on Environment.

Other specific new feature of the text of the law proposal is the introduction of the National program for development and planning in the field of mineral raw materials. This National program defines the scope, goals and guidelines for the geological exploration, as well as the sustainable utilization of mineral raw materials, while respecting the specificities of different areas, the features and distribution of mineral raw materials, and the need for exploitation of mineral raw materials which are crucial for the development of the economy of the Republic of Macedonia.

The new text of the law also proposes that the rights for DGE is to be obtained through an approval that will be issued by the competent body for management of mineral raw materials (until now the right to conduct DGE was obtained through the granting of a concession for DGE). Another novelty in the law proposal is the possibility for transfer of the license for DGE another person, but under the same conditions. Also, the rights from the finished DGE can be transferred to a third person, which is in accordance with the principles of market economy. The right to exploit mineral raw materials will be obtained through the granting of a concession for exploitation of mineral raw materials. There are two ways for the granting of a concession for exploitation of mineral materials which are foreseen. The first one is through a public tender in cases which are stipulated in the National Program for Development and planning in the area of mineral raw materials, as well as when the Republic of Macedonia possess revised elaborates of conducted individual DGE. In accordance with market economy principles, the text provides full or partial transfer of the concession for exploitation of mineral raw materials under strictly defined conditions. The criteria, amount and the method of payment of the concession fees will be determined by the Government of the Republic of Macedonia, in accordance with the principles of market and open economy.

Another important new feature is the allocation of funds received from concession fees.. This law proposal stipulates that half of the funds from concession fees for exploitation of mineral raw materials (which includes thermal mineral waters) are to be transferred to the Budget of the Republic of Macedonia, and the other half to the budget of the Municipality where the exploitation takes place (50%-50%). It also introduces the obligation for rehabilitation of damages caused by the operations of the entity in the course of exploitation of mineral raw materials. The main intention of the new law is to emphasis

the commitment to protecting the environment. Consequently, it imposes an obligation on the performers of the DGE and exploitation of mineral raw materials to comply with the requirements of this law and the Law on Environment and it reinforces the penal policy in the area of exploitation of mineral raw materials and geothermal waters as a mineral raw material.

13. Conclusions

1. Geothermal energy is not a "new" and unknown source of energy in our country. The same is proven in the past with its economic benefit and it is competitive to any other kind of energy source in Macedonia.
2. In eastern and eastern Macedonia, at the moment are registered over 30 springs and occurrences of mineral and thermo-mineral waters with maximum capacity of more than 1.400 l/s and evidenced deposits for exploitation of around 1.000 l/s with water temperatures from 20-79°C, with significant quantities of geothermal energy.
3. The calculation of the valorization of the total balance of the geothermal exploitation reserves in eastern and south-eastern Macedonia (standing 2006) shows: maximum available power is equal to 173 MW or capacity for annual production of 1.515.480 MWh/ year as heat equivalent.
4. Eastern Macedonia has numerous occurrences of thermal and thermo-mineral water that are used in spas and recreational medical centers in the balneology sphere. The geothermal energy from this thermo-mineral water is used in four existing thermal spas with total yield of 250 l/s, total caloric power (heating power) of 35 MW and annual exploitation of 112.5TJ.
5. Taking in consideration that the existing production capacities are based either upon natural springs or shallow boreholes, the maximal current capacity can not give the actual picture for the real capacity of this energetic resource. Based on the existing data it is evident that if supported with relatively small investments in the already started exploration works of these potentials during the 80's of the past century, the capacity could be easily doubled. By providing bigger support it could help to increase and multiply the current capacities over 4-5 times in the next few years. Anyway, the amount of the investments needed for exploration and exploitation of geothermal water wells, points out that without direct support from the state it is not possible to enjoy the benefits of this energy. That is why the Government should treat the geothermal resources as energy of special importance.
6. Further explorations of the geothermal energy above all requires changes in the attitude toward this kind of energy and the dealing with the legislation in this area, which will help to reach a higher level in the utilization of the geothermal waters. This is especially applicable for the hydro geothermal waters with temperatures lower than 40°C that still are not used as energy source. A question which could be imposed here: Is it necessary to adopt special legislation for utilization of the geothermal energy which will define all the aspects in the field of geological explorations and the utilization of this specific energetic resource.
7. Future exploration works in eastern and south-eastern Macedonia should be focused in the already registered areas where there is an indications for increased terrestrial

thermal flow (yield), and registered superficial manifestations from the previous geothermal explorations like in the Delchevo region, broadening of Vinica and Kochani geothermal field, Probishtip region, Radovish region, Dojran - Valandovo-Gevgelija region, in the Vardar zone and the contact-part with the Serbian-Macedonian massif in Bregalnica-Strumica region.

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