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GEOTHERMAL ENERGY IN MACEDONIA, STATE-OF-THE-ART AND PERSPECTIVES

Mirjana Gorgieva[1]; Kiril Popovski[2]; Dusko Gorgiev[3];

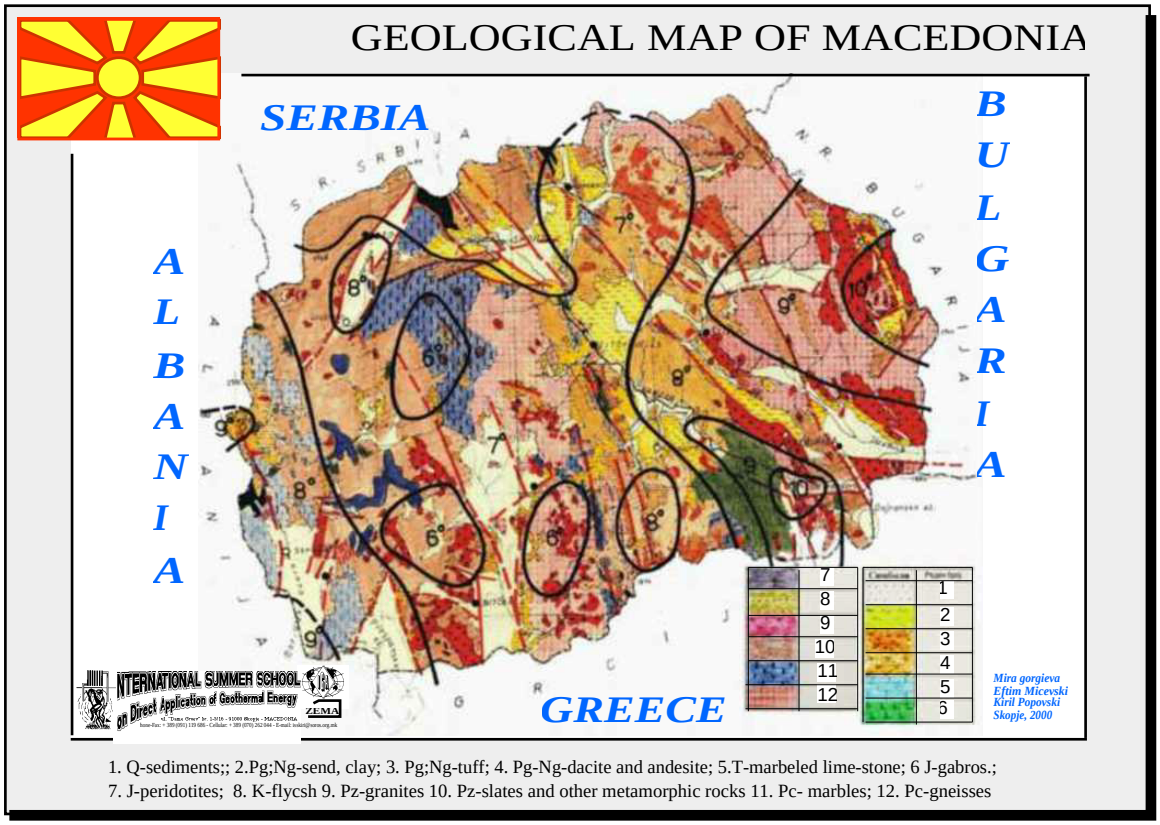
[1] St.Ciryl & Methodius University, Faculty of Science and Mathematics, Gazi baba bb, 1000 Skopje
miragor@iunona.pmf.ukim.edu.mk
[2] St.Kliment Ohridski University, Faculty of Technical Sciences, Ivo Ribar Lola bb, 7000 Bitola
isskiril@sonet.com.mk
[3] Domis, Mito Hazivasilev Jasmin 20/3, 1000 Skopje
domis@unet.com.mk

Fig.1. Map of Macedonia

ABSTRACT

The geothermal zone spread in Macedonia is associated with geothermal manifestations (mainly hot springs and wells with temperature from 20-79^{0}C) at more than 50 localities.

It is believed that only low temperature fields exist. Almost all hydrogeothermal systems are related to an ancient subduction zone of Jurassic age, along the Rodopian mass and Dinarides known as Vardar tectonic unit. The most important hydrogeothermal systems are in the Skopje valley, Kochany valley, Strumica valley, Gevgelia valley, and Kozuf Mountain and Kratovo-Zletovo volcanic area.



1. Q-sediments;; 2.Pg;Ng-send, clay; 3. Pg;Ng-tuff; 4. Pg-Ng-dacite and andesite; 5.T-marbeled lime-stone; 6 J-gabros.;
7. J-peridotites; 8. K-flycsh 9. Pz-granites 10. Pz-slates and other metamorphic rocks 11. Pc- marbles; 12. Pc-gneisses

Fig.2. Geological map of Macedonia

GEOLOGICAL FRAMEWORK AND TECTONIC SETTING OF MACEDONIA

In the territory of Macedonia rocks of different age occur, starting from Precambrian to Quaternary. Almost all lithological types are represented. The oldest, Precambrian rocks, con-sist of gneiss, micaschists, marble and orthome-tamorphites. The rocks of Paleozoic age mostly belong to the type of green schists, and the Mesozoic ones are represented by marble limestones, acid, basic and ultrabasic magmatic rocks.

The Tertiary sediments consist of flysch and lacustrine sediments, sandstones, limestones, clays and sands.

With respect to the structural relations the territory of Macedonia can be divided into six geotectonic units: The Cukali-Krasta zone, West Macedonian zone, Pelagonian horst anticlinorium, Vardar zone, Serbo-Macedonian massif and the Kraisthide zone, Fig.1. This tectonic setting is based on actual terrain and geological data without using geotectonic hypothesis (Arsovski, 1998). First four tectonic units are parts of Dinarides, Serbo-Masedonian mass is part of Rodops and the Kraisthide zone is part of Karpato-Balkanides distinguished on the Balkan peninsula as geotectonic units of first stage.

GEOTHERMAL BACKGROUND

The territory of the Republic of Macedonia belongs to the Alpine-Himalayan zone, with the Alpine subzone having no contemporary volcanic activity. This part starts from Hungary, across Serbia, Macedonia and north Greece and stretches to Turkey. Several geothermal regions have been distinguished including the Macedonian region, which is connected to the Vardar tectonic unit. This region shows positive geothermal anomaly hosting different geothermal systems, Fig.3.

The hydrogeothermal systems, at the moment, are the only systems that are worth investigation and exploitation.

In the Republic of Macedonia there are 18 geothermal fields with more than 50

thermal springs, boreholes and wells with hot water. These discharge almost 1.400 l/s water flow with temperature of 20-79 ^{0}C. Some of this water is used for heating hotels and greenhouses, some for balneology purposes and some discharge without being used.

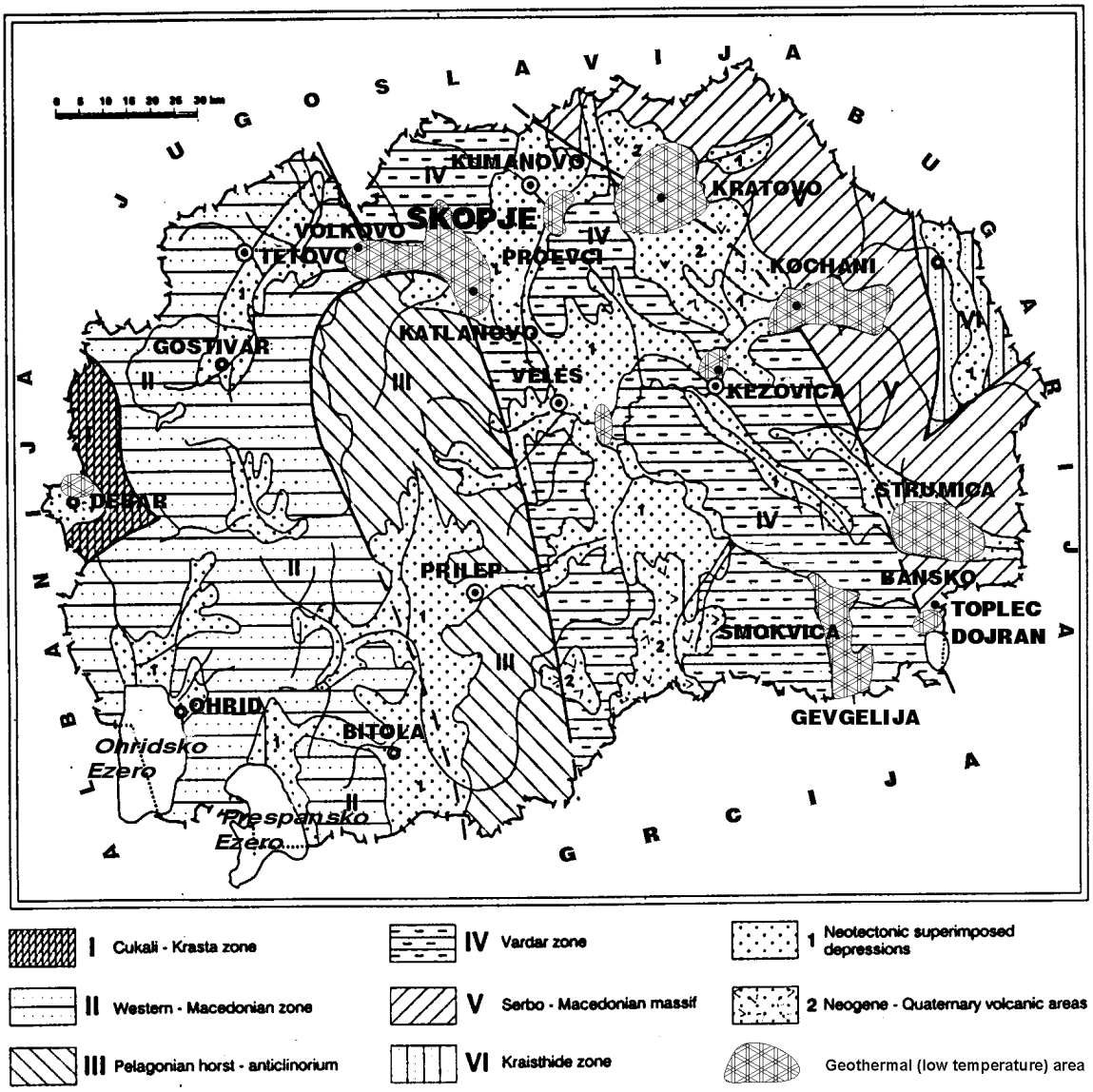
The hot waters in Macedonia are mostly hydrocarbonate according to their dominant ani-on, and mixed with equal presence of Na, Ca and Mg. The dissolved minerals range from 0.5 to 3.7 g/l.

All thermal waters in Macedonia are of meteoric origin. Heat source is the regional heat flow, in the Vardar zone is about 100 mW/m^2 and crust thickness 32 km.

GEOTHERMAL FIELDS IN MACEDONIA

There are 18 localities where geothermal fields occur and geothermal energy is in use for different proposes, Table 1. The most known areas are listed below.

Fig.3. Map of regional tectonic setting of Macedonia (Arsovski, 1998) with main geothermal (low temperature) areas



Kochani valley

The main characteristics of the Kochani valley geothermal system are: presence of two geothermal fields, Podlog and Istibanja, without hydraulic connection between them; a primary reservoir is build by Precambrian gneiss and Paleozoic carbonated schists;

the highest measured temperature in Macedonia of 79^{0}C obtained by drilling; the predicted maximum reservoir temperature about 100^{0}C. The Kochani geothermal system is the best investigated system in Macedonia. There are more than 25 boreholes and wells with depths of 100-1.170 m.

The usage of thermal waters in Kochani valley is given in Table 1.

Strumica valley

There is one geothermal field in the Strumica valley, Bansko in the village Bansko.The main characteristics of this field are: the recharge and discharge zone occur in the same lithological formation-granites; there are springs and bore-holes with different temperature at small distances; maximum measured temperature is 73^{0}C; the predicted maximum temperature is 120^{0}C (Gorgieva, 1989); the reservoir in the granites lies under thick Tertiary sediments. Bansko geothermal system has not been examined in detail apart the drilling of several boreholes with depths of 100-600m. Thermal water is use for greenhouse and heating, Table 1.

Gevgelia valley

There are two geothermal fields in the Gev-gelia valley: Negorci spa and Smokvica.The discharge zone in both geothermal fields are fault zones in Jurassic diabases and spilites. Although these two fields are separated by several km there is no hydraulic connection bet-ween them, despite intensive pumping of ther-mal waters. The maximum temperature is 54^{0}C, and the predicted reservoir temperature is 75-100^{0}C. The geothermal system in the Gevgelia valley has been well studied by 15 boreholes with depths between 100-800 m. Thermal wa-ters are used as listed in the Table 1.

Skopje valley

There are two geothermal fields in the Sko-pje valley: Volkovo and Katlanovo spa. There is no hydraulic connection between them. The main characteristics of the Skopje hydrogeo-thermal system are: maximum measured temperature of 54.4 ^{0}C and predicted reservoir temperature, by chemical geothermometers, of 80-115^{0}C (Gorgieva, 1989); the primary reser-voir composed of Precambrian and Paleozoic marbles; big masses of travertine deposited during Pliocene and Quaternary period along the valley margins. There are only five borholes with depths of 86m in Katlanovo spa, 186 and 350 m in Volkovo and 1.654 and 2.000 m in the middle part of the valley. The last two boreholes are without geothermal anomaly and thermal waters because of their locations in Tertiary sediments with thickness up to 3.800 m.

PERSPECTIVES FOR GEOTHERMAL FIELDS IN MACEDONIA

Even with a long tradition in geothermal energy use for greenhouses heating Macedonia doesn't have organized state approach to this economy sector. The perspective in Macedo-nian geothermal fields depends of foreign in-vestment. There is action in Katlanovo spa to introduce geothermal heating in the buildings and modernization of the spa capacities. The World Bank pre-feasibility study resulted with positive economical justification of the neces-sary investments. Few years ago there were investments from Austrian Government applied in geothermal field Istibanja and Podlog.

Table 1. State-of-the-art of the geothermal energy use in Macedonia

GEOTHERMAL LOCATION	GEOTHERMAL FIELD	APPLICATION	HEAT POWER TOTAL KW	GEOTHERM KW	HEATING INSTALLATION
Kochani valley	Istibanja	Greenhouse heating (6.0 ha)	17.500	2.350	Aerial steel pipes
	Podlog	Greenhouse heating (12.0 ha)	40.700	20.500	Aerial steel pipes
		Rice drying,	1.600	1.600	Square finned pipers heat exchanger
		Paper industry,	3.200	3.200	(water/air)
		Space heating	650	650	Plate heat exchanger Al and Fe radiators
Strumica valley	Bansko	Greenhouse heating (2.9 ha)	9.000	9.000	Aerial steel pipes and surface steel pipes
		Greenhouse heating (600sq.m)	150	150	Corrugated PP pipes on surface+fan jet air
		Plastichouses heating (3.0 ha)	3.000	3.000	heating Soil heating
		Space heating	1.560	1.560	
		Sanitary warm water preparation	700	700	Al radiators Plate heat exchanger
		Swimming pool heating	350	350	+warm water accumulator
		Balneology			Plate heat exchanger
Gevgelia valley	Smokvica	Greenhouse heating (22.5 ha)	65.500	11.750	Aerial steel pipes + corrugated PP pipes
		Plastichouses heating (10.0 ha)	10.000	10.000	on surface Corrugated PP pipes on surface
	Negorci spa	Space heating Balneology	250	250	Steel radiators
Skopje valley	Volkovo	Gasses exploitat. Bottling			
	Katlanovo spa	Balneology			
Kumanovo	Proevci spa	Bottling			
Stip	Kezovica spa	Balneology			
Debar	Debarska spa	Balneology			
	Kosovrasti spa	Balneology			
Kratovo-Zletovo	Strnovec	no use			
	Povisica	bottling			
Kozuf mountain	Topli dol	bottling			
	Mrezicko	bottling			
	Toplik	no use			
TOTAL	62,46 ha greenhouses 82.560 kw Space heating (5 units) Paper industry (1 complete) Sanitary warm water preparation (2 units) Rice drying (1 unit) Swimming pool heating (1 unit) Balneology (8 spas) Bottling mineral water (5 projects) Gases exploitation (1 unit)				

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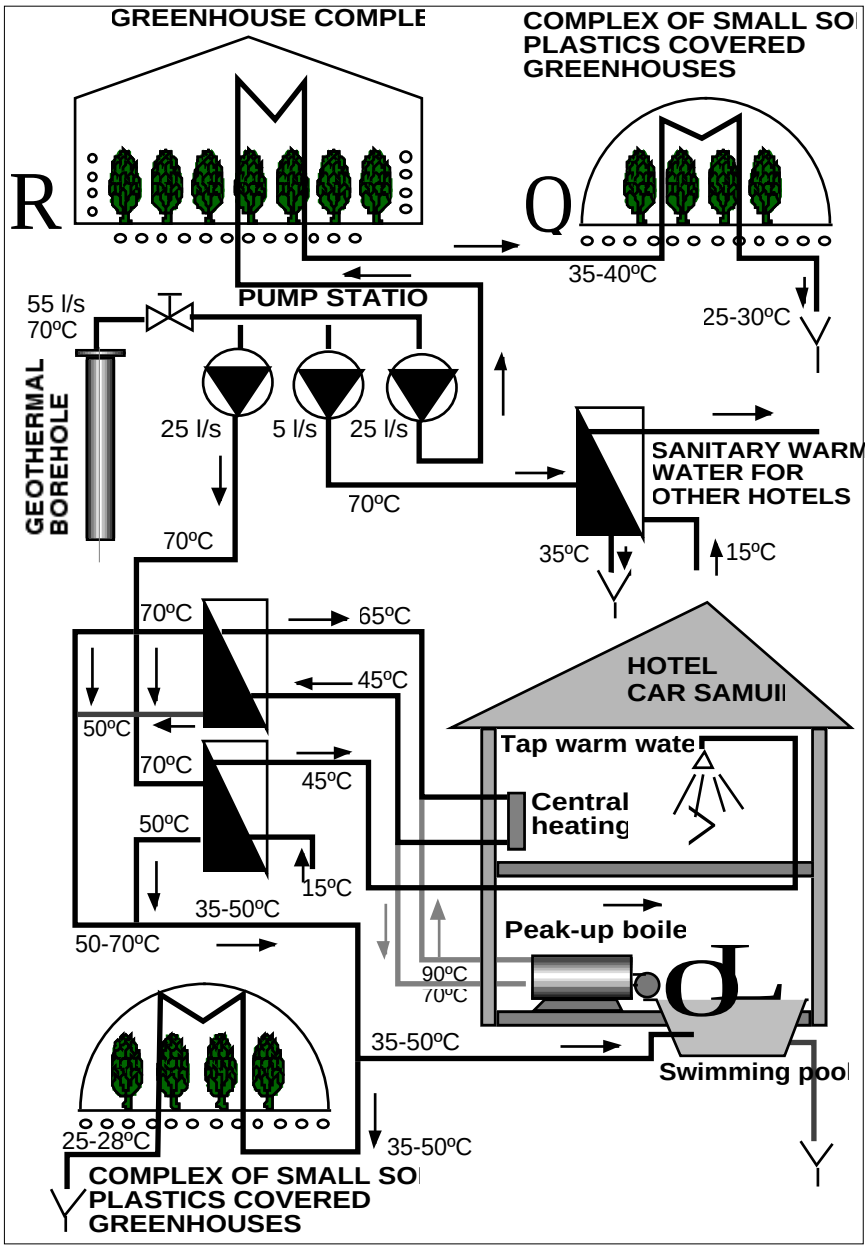

Fig.4. Scheme of the geothermal system Bansko (Popovski, 2002)