NOTICE CONCERNING COPYRIGHT RESTRICTIONS

This document may contain copyrighted materials. These materials have been made available for use in research, teaching, and private study, but may not be used for any commercial purpose. Users may not otherwise copy, reproduce, retransmit, distribute, publish, commercially exploit or otherwise transfer any material.

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted material.

Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specific conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

This institution reserves the right to refuse to accept a copying order if, in its judgment, fulfillment of the order would involve violation of copyright law.
7. The Rolling Ball of History: Geothermal Resources in Macedonia

by Kiril Popovski
Konstantin Dimitrov

Abstract: At the crossroads of eastern and western civilizations, Macedonia always has been a place where one can feel at home by discovering around oneself a great part of familiar culture. Geothermal resources are one such link. Rich in geothermal resources, Macedonia combined the old Greek and Roman use of natural hot water for public baths with the Turkish concept of “cleansing” the body and soul by using steam and hot water.

INTRODUCTION

Geographically, Macedonia is situated at the south-central part of the Balkan peninsula, which accounts for its historical and strategic importance as a crossroads for connections between Europe and the Near East and as an exit from the Central/Eastern European region to the warm waters of the Mediterranean Sea. It is the region that protected ancient Greece from northern “barbarian” invasions but also the region from which Greece finally was invaded. It was for centuries one of the most important trade and military connections for the Roman Empire (Via Egnatia) and, later, the Ottomans. Macedonia is also the route whereby Turkish troops tried to enter Central Europe and through which the Crusaders passed on their way to the Holy Land.

Traces of all these cultures can be found in Macedonia today, mixed and expressed in different ways. Alexander the Great invaded Greece, but at the same time he introduced Greek
culture to Macedonia and paved the way for its permanent presence through religious and governmental dominance (the Eastern Orthodox Church and the Byzantine Empire). Roman culture is apparent even today, in the languages of the Albanians and Vlachos, spread along a part of the old Via Egnatia. Five centuries of Turkish government resulted in a great concentration of Moslems. Finally, the Macedonian nation still keeps a part of its original Slavic culture, brought 1,500 years ago from the northern part of the continent.

When speaking about geothermal resources and their rich and varied uses, one should not forget that geothermal development has been influenced by this cultural “mixture” characterizing the development of the original Macedonian culture. Rich in geothermal resources, Macedonia took the old Greek and Roman use of natural hot water for public baths and the Turkish pleasure of “cleansing” the body and soul by using steam and hot water. Many “miracle” springs can be found, offering successful medical treatment and “new youth” in the best Slavic Northern European tradition.

Unfortunately, there has been no systematic investigation of past development of geothermal resource usage. One can have only a rough orientation based on the archaeological record, rare written documents, oral tradition, and traditional local “know-how” for medical and heating purposes. This chapter presents a part of the information available, mainly collected by geologists and hydrologists at geothermal locations.

BACKGROUND

MACEDONIAN TERRITORY IS CHARACTERIZED BY A VERY COMPLEX GEOLOGICAL-TECTONIC structure. Although the Earth’s crust can be up to 40 km thick in Macedonia, some areas are very promising for the occurrence of high-enthalpy geothermal resources. This is due to the emplacement of numerous granite intrusions which, during their crystallization, supplied the surrounding rocks with enormous amounts of heat. Numerous surface manifestations can be found all around the country; nearly every village has some mineral sources.

About 200 natural mineral and thermo-mineral springs have been identified within the Republic of Macedonia (Kotevski, 1987), and the situation is similar in locations which now belong to Greece and Bulgaria. Most of the springs have been known and used for ages, mainly for health, but also for agricultural production, industry, and other heating purposes.
Four general geothermal zones can be identified: the Bosnian-Serbian-Macedonian, Pannonian, Alpine, and Dinaride. These can be subdivided into areas, each with its own particular characteristic and potential. From the geotectonic point of view, the Bosnian-Serbian-Macedonian geothermal area is situated in the internal Dinarides, the Serbian-Macedonian massif, and the Carpato-Balkanides. Plutonic and volcanic rocks, Neogene in age, are most common; thus, realistic possibilities exist for the presence of hydrogeothermal and petro-geothermal energy. Although numerous surface occurrences are known, closer definition of the geothermal resources is rather difficult and complex due to fractures, joints, and cave systems in Paleozoic and Mesozoic rocks.

The geology of Macedonia, according to G. Kotevski, 1993: (1) Corabides; (2) West Macedonian zone; (3) Pelagonidic horst-anticlinorium; (4) Vardar zone; (5) Serbo-Macedonian massif; (6) Struma zone.

Geothermal locations in Macedonia and surrounding countries.
The seven geothermal fields found in Eastern and Northeastern Macedonia are grouped according to geotectonic divisions. The eastern and northeastern areas are part of the Macedonian-Serbian massif characterized by crystalline basement rocks. These areas are much richer than the western and southwestern regions, which are characterized by limestone.

**History**

There has been no systematic investigation of the history of geothermal resource use and development in Macedonia. Rough data from written documents are available, but what is known comes mostly from the oral traditions of local people and archaeological sites. The last scientist who collected data about previous uses of Macedonian thermal waters was Dr. Georgi Kotevski. His doctoral work on the hydrogeology of mineral and thermo-mineral waters in Macedonia included a list of natural sources with their characteristics and data about previous and present uses (1987). G. Velenis gave some information in his 1988 paper on the history of thermal baths in Greece, and Dr. Shterev investigated geothermal resources in the Bulgarian part of Macedonia and published information about those in the eastern part of the Republic of Macedonia (1992). Popovski published useful information, mainly on new applications (1987).

It is necessary to emphasize that all of the information about geothermal applications in older historical periods are interpretations and suppositions based on the oral traditions of local people, in combination with archaeological sites (ruins, old baths, pictures, and mosaics). Further investigation can give more precise information on specific sites and applications and can correct some of the conclusions, but the main concepts will remain.

Eight historical periods of geothermal application in the Republic of Macedonia can be identified. They are discussed in the following sections.

**Ancient Macedonian and Greek Period (until 197 B.C.)**

While there is no proof about geothermal uses during this period, after the introduction of Greek culture to Macedonia, a number of elite people (Aristotle, for example), as well as statesmen and traders, came to the region, bringing with them their Greek customs. Social customs included hot baths, but it’s possible that Macedonians used naturally warm and hot flows before the arrival of the Greeks, since the waters are located near towns.
ROMAN PERIOD (200 B.C.-395 A.D.)

Romans and their "thermae" are known as the real founders of the public use of thermal waters. Therefore, it's not strange that in Macedonia they used available hot resources, particularly during the colder months. Ruins of an old Roman bath can be found near Banja Bansko (Kotchany), old Roman coins in the ruins of the old bath in the Katlanovo Spa (Skopje), and some indications of possible applications at Bansko (Strumica).

BYZANTINE EMPIRE (395-1340)

The East Roman Empire, later known as the Byzantine, followed the state organization and tradition of the Roman Empire but also was influenced by the cultures of the different nations composing it. While there is no direct evidence, during this period the use of thermal baths apparently slowly disappeared from Macedonia. The Christian religion looked unkindly on the exposure of the human body, especially to the eyes of the opposite sex or children. Also "internal" hygiene became more important than "external."

OTTOMAN EMPIRE (1340-1918)

When coming to the Balkan peninsula, the Turks brought a strong military organization and a new approach to hygiene. While all Moslems had to be clean before praying in the mosque and it was a national tradition to take baths whenever possible for cleanliness, the Turks also took pleasure in being refreshed after taking a hot bath and perspiring in steam. Macedonia is littered with ruins of old Turkish thermal baths, like those in Bansko (Strumica), Gabrovo (Deltchevo), Negorci Spa (Gevgelija), Kezhovica (Shtip), Kosovrasti, and Debar Spa (Debar).

Turkish bath at Strumica, Republic of Macedonia. J. Lund
THE KINGDOM OF SERBS, CROATS, AND SLOVENIANS (1918-1941)

After the Balkan and First World Wars, the territory of Macedonia was divided among the four new states (Albania, Bulgaria, Greece, and SHS). The country was destroyed and major population movements resulted in a changed national structure and, therefore, a changed way of life. Many of the Turkish thermal baths were abandoned, but some were reconstructed (Katlanovo, 1930) and new ones arose (Debar, 1925). However, on the average, geothermal baths decreased in comparison with previous periods. It’s necessary to stress that this was also the period when the first serious geological and geothermal investigations were conducted by F. Kosmat (1924); K. Osswald, A. Burm, and Ermansdorfer (1924-25); Cripp (1921); and others.

FEDERATIVE REPUBLIC OF YUGOSLAVIA (1945-1963)

After World War II when the Federative Republic of Yugoslavia was established, communist support for all matters involving “public” interest assumed principal importance, stimulating the development of thermal baths for medical and tourism purposes.

Katlanovo Spa, Negorci Spa, Kezhovica, and Debar Spa were modernized, and the first geothermal greenhouse in Bansko (1976) was put into operation. Intensive geological and geothermal investigations resulted in the identification of most of the geothermal fields known today. Vidakovich, Popovich, and Sibinovich (1953); S. Miholich (1955); T. Mitrov, D. Gjuzelkovski, N. Izmailov, and K. Jenko (1955-56); A. Kekich (1961); V. Cirich (1971); G. Kotevski (1971-79); and others started developing these resources in the Republic of Macedonia.

SOCIALIST REPUBLIC OF YUGOSLAVIA (1963-1991)

A change in the economy after 1963 heavily influenced the development of geothermal resources. The first really modern spa was built in Banja Bansko (Strumica), equipped with geothermally heated rooms, halls, and a swimming pool, as well as facilities for medical treatments with geothermal water. The energy crisis of the 1970s stimulated development of geothermally heated greenhouses and, during that time, Macedonia led the world with this type of geothermal application.
Also during this period, the Negorci Spa was equipped with geothermally heated rooms, and development began of the Kotchany geothermal district heating system. Scientists and engineers like Kotevski, Andrejevski, Micevski, Tcherepnalkovski, Neunov, Gashteovski, Dimitrov, and Popovski are firmly connected with the "flowering" of geothermal development in Macedonia. In 1989, Popovski established the International Summer School on Direct Application of Geothermal Energy, in collaboration with colleagues from Italy (Fanelli, Dickson), Greece (the Martzopoulouses), Macedonia (Dimitrov), and later on from France (Jaudin), Bulgaria, and Romania.

**Republic of Macedonia (1992-present)**

The period of recent development has been very short. After the end of the "energy crisis" and the decline of Yugoslavia, the Greek embargo, and problems of political and economic transition, it stopped completely. The geothermal project in Vinica has been abandoned and those in Gevgelia, Bansko, and Kotchany are stagnant. Some small activities by the enthusiasts in Kotchany and Gevgelia are apparent, but those cannot change the picture of total stagnation. This situation can change only after the period of privatization and economic transition ends, since geothermal resource application is not a principal interest of a country faced with very complex political and economic situations.

**Application Technologies**

As previously noted, there is no information about geothermal use during ancient Macedonian times. If one assumes that the use itself came with the Greeks, open air natural pools or pools made by partitioning natural warm water flows can be a realistic supposition.

For the Romans, however, a realistic picture can be reconstructed. Open air pools were augmented with stone or brick side walls and bottoms in the first phase of development. Then, a bathhouse was added that later became a pleasant place for conversing after a bath, from benches lining the inside walls. The last development was the introduction of floor heating.

Effluent water from the pool, except that directly released to the environment, flowed below the floor surface through a system of ceramic tubes or brick channels made of stone cubes or bricks. In that way, the bathhouse, originally intended as a cloak room, became a social
gathering spot. Many windows ensured continual fresh air flow, which was very pleasant during the hot summers. The hot floor allowed the room temperature to be increased in colder weather. In the best Mediterranean tradition, it was normal that massage, refreshments, and news were available, and that was the reason why the thermae were among the most popular public places in town.

Unfortunately, the social aspect of the Roman baths was also the reason for their downfall. Very soon after the introduction of Christianity, thermae were identified as decadent. Naked or half naked men and women together in a free atmosphere was opposite from the way of life condemned by the new religion, and slowly, thermal baths were abandoned during the end of the Roman era and the beginning of the Byzantine.

During the Byzantine era, another use for mineral and thermo-mineral waters became popular. Many of them were considered magic, falling under the protection of a saint because they helped to cure many diseases. The Orthodox Church supported this development by establishing monasteries and hospitals near such “miracle” sources. Traces of such treatments can be found even today. For instance, the name of the spring Sabota voda means that the water is curative only on Saturdays.

The situation changed when Turks came to Macedonia, bringing another use for water in general and hot water in particular. In addition to continuing the Roman tradition of taking baths in warm and hot water, they also cleansed the body by steaming. That was the background of the characteristic construction and composition of the Turkish baths: a shallow pool with warm or hot water in a completely closed room, full of steam, with very small openings on the top of the oval roof. Hot water served as both the source of the steam and the heating system. A bathhouse,
positioned beside the pool, was used for clothing changes, and the pool room itself became the social room. For a small amount of money, one could be washed by an attendant, be offered sweats and cold water, and have a pleasant chat with friends, all at the same time. It’s not strange that every town in Macedonia had a Turkish bath, and, where thermal water was available, they were using it. Beautiful examples of Turkish baths in Skopje and other towns reflect the original organization, shape, and construction details.

Baths from the first half of the 20th century have added nothing new to the technology of geothermal water application. They are typically shallow pools, in a closed room, made of cement covered with ceramic plates. Hot water is also used for special medical treatments (baths in mud or bathtubs). Older spas are not equipped with central heating; they use just the heat of the warm water, supplemented by wood stoves for colder days.

The first complete geothermal project is the Hotel Tsar Samuil in Bansko, Strumica, which provides nearly all of the hotel’s heating needs. The heating system consists of radiators in the rooms and air heaters in the hallways. Heat from geothermal water is extracted with a plate heat exchanger, and a second heat exchanger supplies heat for sanitary warm water and hot water for the kitchen. Used water from both heat exchangers goes to the swimming pool and for medical treatments. Finally, the effluent water from the system is used by farmers to heat greenhouses. On very cold days, a pickup boiler augments the geothermal heat. This system is part of a larger geothermal system, which also heats a greenhouse complex.

Two applications of this system are of particular importance: first, small farmers knew immediately how to use the hotel’s effluent water to heat the floors of small greenhouses; secondly, the...
first totally geothermally heated greenhouse in the world was completed here. The first application illustrates the knowledge of old technology (Roman and Turkish baths), and the second represents a pioneering approach to geothermal resources as "normal" energy resources. That is why the Bansko integrated geothermal system has historical significance, not only for Macedonia but beyond.

Finally, and probably the most important illustration of technological "know-how" for direct geothermal application in Macedonia, is the integrated geothermal district heating system in Kotchany. It is still under development but can be used for a variety of purposes: agricultural (heating greenhouses and drying rice), heating dwellings and preparing sanitary warm water, and industrial (the paper industry). Some of the applied technical solutions are very sophisticated (geothermal-water distribution system without compensators for thermal expansion and contraction over a 6 km length), some are very old fashioned (heating systems in greenhouses), and some are simplistic (projects with existing heating installations connected to the geothermal district heating system). But altogether, it's one of the largest geothermal systems in the world.

CONCLUSIONS

AN OLD COUNTRY LIKE MACEDONIA HAS AN OLD HISTORY OF GEOTHERMAL APPLICATIONS. However, little concrete evidence exists for us to know exactly when and how geothermal resources were developed. The reason is that virtually no serious investigations have been conducted to clarify this part of Macedonian history.

Archaeological sites and local oral traditions indicate a rich but very changeable history and development of this resource. The history is characterized by flourishing periods lasting for centuries but also deep recessions lasting for many, many years. Different civilizations passed through the country, and each one left traces of a specific approach to this "unimportant" part of life. Ancient Macedonians, under the influence of the Greeks and Romans, adored life and the human body, and it was natural that they discovered and used the benefits of natural warm and hot water resources, enabling pleasant baths and relaxation. The rigors of early Christianity ran contrary to ancient practices and nearly destroyed previous social customs.

However, history is like a rolling ball. The Turks succeeded the Byzantine Empire, and they again reaped the benefits of the Earth's fire. The civilization of today is both built on and enriching the technology of the past.

112
SELECTED REFERENCES


The Authors:

Kiril Popovski  
St. Clement of Ohrid University—Bitola  
Faculty of Technical Sciences  
Ivo Ribar Lola, bb  
97000 Bitola, Republic of Macedonia  
Telephone/Fax: 389.91.119.686

Konstantin Dimitrov  
Sts. Cyril & Methodius University—Skopje  
Faculty of Mechanical Engineering  
Naselba Karpos 11, bb  
91 000 Skopje, Republic of Macedonia  
Telephone: 389.91.363.566  
Fax: 389.91.362.298
Hydrothermal minerals (kaolin, sulfur, alunite, and iron oxides) are found on the islands of the Aeolian archipelago, Italy. Many manifestations of this type formed in Southern and Central Italy during recent geological times. Their products were used in prehistoric epochs for a number of purposes. Prof. A. Sbrana, University of Pisa, Department of Earth Sciences