

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.



17. Using Geothermal Energy in Poland in the Second Millennium

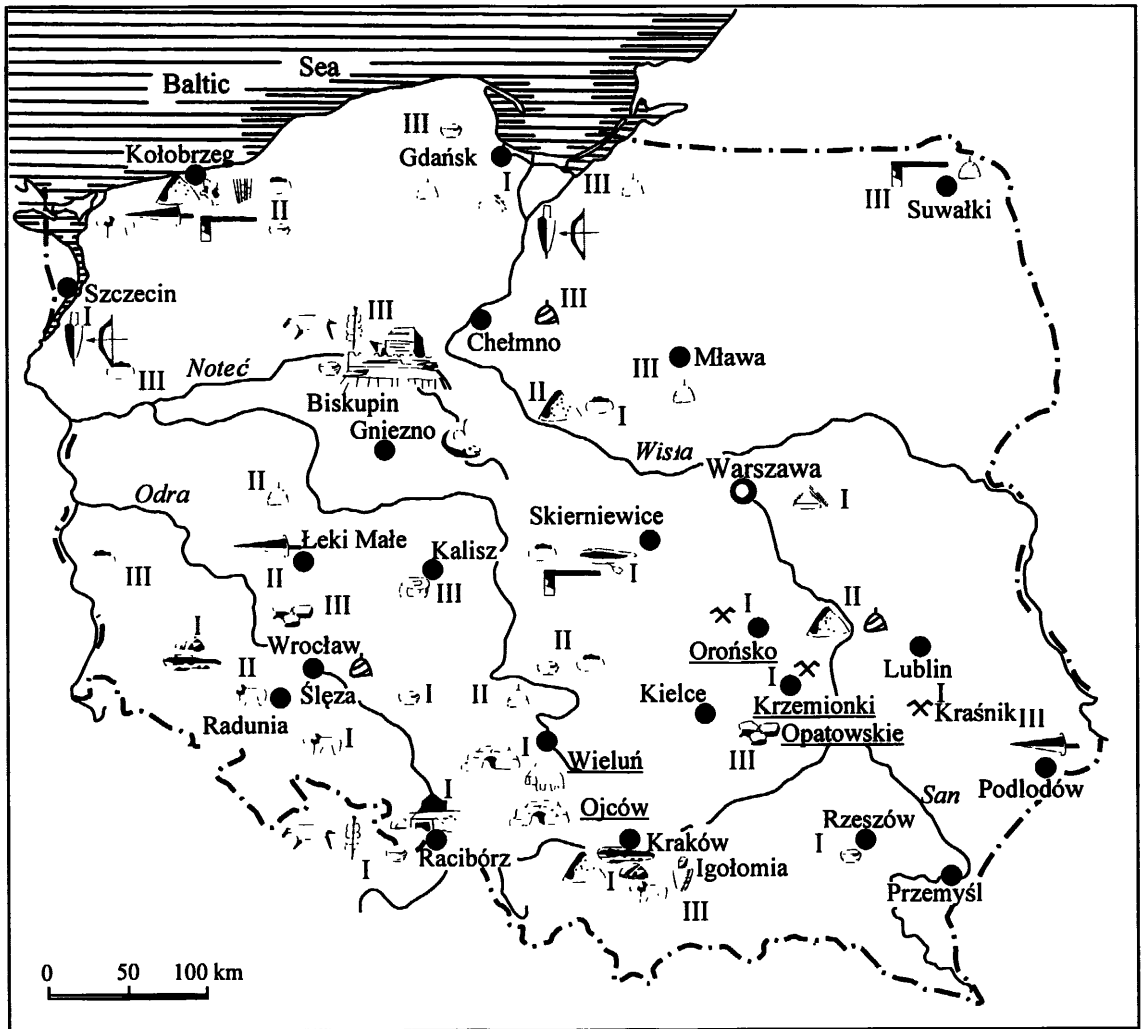
by
Julian Sokolowski
Jozefa Sokolowska
Beata Kepinska

Abstract: Due to geological and geothermal conditions, Poland is characterized by low to moderate heat flow values. The only signs of the Earth's heat at the surface are a few dozen geothermal springs with temperatures between 18° and 44° C, located in Central Poland (Polish Lowland), the Sudetes region (Lower Silesia), and in the southern sector of Poland (Carpathian Mountains). Some of these springs were probably known and used since prehistoric times, but the systematic use of Polish geothermal waters for curing purposes began about 1,000 years ago. Since then, the tradition of thermal bathing has increased progressively, suffering temporary recessions as a result of conflicts and political changes that have affected Central Europe, Poland in particular, from the beginning of the second millennium to the mid-20th century.

INTRODUCTION

THE USE OF GEOTHERMAL HEAT HAS ACCOMPANIED THE development of people since the beginning of their existence on the planet. Initially, this heat helped people survive cold periods of a changing climate: prehistoric people managed to find shelter in caves and, especially in winter, they harnessed natural heat from geothermal sources whenever possible. Examples of such behavior are apparent in Poland, confirmed by numerous archaeological findings dating back to the Upper Paleolithic-Neolithic and to the Bronze and Iron Ages. Major archaeological sites are shown on the map.

Stone Age artifacts include pottery, flint tools, arrows and spears, fishing tools, and traces of fortified strongholds. Among the most important Neolithic findings are the underground flint mines in the Oronsk, Krzemionki Opatowskie, and Krasnik regions and by the Kraków-Wielun Jurassic caves, which were inhabited from at least 5000 B.C. In addition, numerous



LEGEND			
I	Stone Age	II	Bronze Age
III	Iron Age		
	Dugouts		Fortified Strongholds
	Powerful Cities		Flint Mines
	Saltworks		Iron Production
	Fishery		Agriculture and Breeding
	Weaving and Tanning		Pottery
	Graves, Tombs, and Cemeteries		Flint Tools
	Bows, Arrows, and Spears		Axes
	Swords		Canoes
	Pottory		Caves
	Mammoth Remains		Jewelry
	Coins		Cult Locales

Main archaeological sites and findings in Poland. The underlined localities are inhabited caves and underground mines where ancient people took advantage of natural heat. *Compiled by the authors*

objects and utensils dating back to the Bronze Age have been found in the central and northern parts of the country. The most spectacular Iron Age site is a reconstructed fortified settlement in the Biskupin area. Other Iron Age artifacts include ceramics, pottery, coins, and graves and cemeteries.

Starting probably from the Upper Paleolithic, and certainly from the Middle Neolithic, people settled in Poland and began to take advantage of the relatively warm environment and constant temperatures in natural caverns warmed by the Earth's heat. The heat also made it easier for the people to mine flint and ore veins. In fact, flint tools from Poland have been exported to a number of Northern European regions since ancient times.

HISTORICAL HIGHLIGHTS

“MODERN” POLISH STATEHOOD BEGAN IN 966, SANCTIONED BY THE BAPTISM OF MIESZKO I. Written records about the establishment of governance date to that time, as well as written information concerning the occurrence and use of geothermal springs in certain parts of Poland. From the year 1000, countless documents provide evidence that Poland has often changed its area and property. The present borders, however, approximate those established around 1000.

The frequent fluctuations of Poland's boundaries over the past 10 centuries resulted in localities with warm springs changing their national ownership from time to time. Regardless of whether they belonged to Poland or nearby countries, however, and despite political circumstances, the warm springs of present-day Poland have always attracted people from Central Europe because thermal facilities were relatively unaffected by political downfalls and were often protected by temporary governments and local administrations. For this reason, geothermal spas could develop in Poland over the centuries. The main historical highlights of Poland follow, illustrating the territorial changes within which thermal bathing developed.

The first Polish ruler, Mieszko I (960-992), ruled over two different regions traced back to the mid-10th century: one belonged to the “Polans” and the other to the “Vistulans.” At the end of Mieszko I's reign, these two regions united to form the first Polish nation, including the nearby lands of Slavonic tribes; its first bishopric was established in Poznan.

During the time of Boleslaw Chrobry (992-1025), other bishoprics were established in Gniezno, Kolobrzeg, Wroclaw, and Kraków. Records from that time indicate that warm springs were

known and had probably long been in use by local people in the region of present-day Jelenia Gora and Cieplice. The latter name means “warm springs.”

During the reign of Boleslaw the Skew-Lipped (1107-1138), new bishoprics were established in Lubusza at Oder and at Plock. On his death, Poland was partitioned among his sons.

In 1306-1333, some previous Polish territories were reunited under Wladyslaw the Elbow. During this period, the caves of Ojcow-Wielun, located near Kraków (then the Polish capital), were used temporarily by people as places of refuge during invasions of foreign troops. However, some caves in the Tatra Mountains and in the Swietokrzyskie (“Holy-Cross”) Mountains were also used as shelters by bandits.

Wladyslaw the Elbow’s successor, Casimir the Great, broadened the Polish borders and strengthened both the defense system and the Polish economy.

Under King Wladyslaw Jagiello (1386-1434), the Polish Kingdom united with the Great Lithuanian Kingdom. The territories of the new political entity extended as far as the Black Sea and included important towns such as Polock, Smolensk, and Kiev. However, the southwestern part of Poland, together with Lower Silesia and such important towns as Wroclaw, Opole, and Jelenia Gora (Cieplice), passed to the rule of the Czech crown.

Under the reigns of Sigismund III (1587-1632) and Wladislaw IV (1632-1648), the united Polish and Lithuanian Kingdoms were first called “Crown,” then “Polish Republic I.” In the years following the Swedish invasion (1655-1660), under Jan III Sobieski (1674-1696), the Polish territory still extended to the east as far as Kiev.

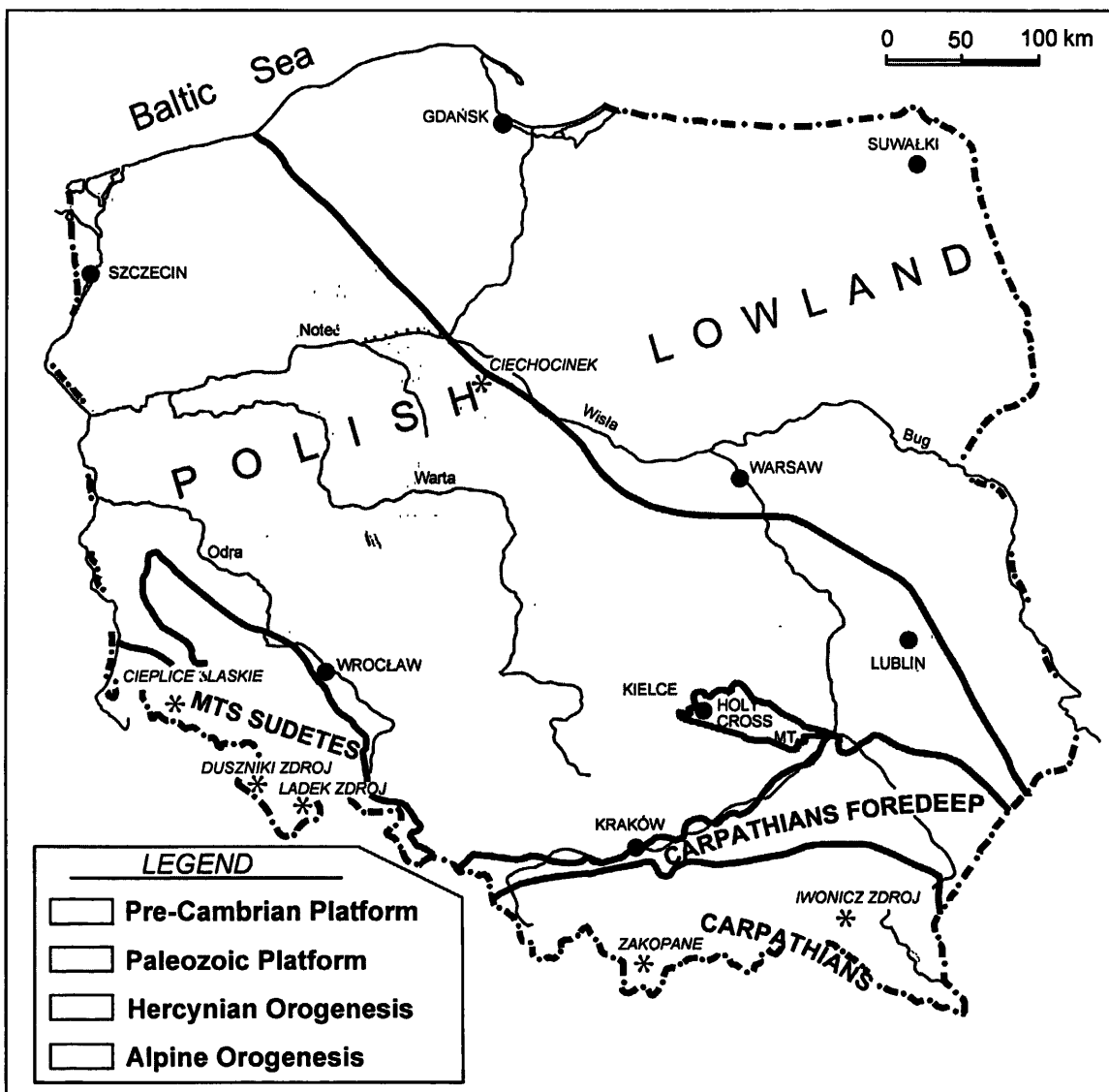
During 1772-1793, the Polish territory was partitioned among Austria, Prussia, and Russia. However a small area, called the Polish Kingdom with its capital in Warsaw, remained untouched and formed the core of the new Polish nation that emerged in 1918 with new borders, the “Polish Republic II.”

This new nation flourished until 1939, when it was again divided as a result of World War II. In 1945 after the end of the war, the new borders of Poland were restored to more or less what they were 1,000 years ago.

GEOLOGICAL AND GEOGRAPHICAL BACKGROUND

THE POLISH TERRITORY CAN BE DIVIDED INTO THREE MAIN GEOLOGICAL REGIONS:

- The Polish part of the Middle-European Epiplatform Province: it consists of a fragment of the Pre-Cambrian East-European platform (Northern and Eastern Poland) and a fragment of the Paleozoic West-European platform (Western and Central Poland). The older formations are covered by thick Permian, Mesozoic, and Cenozoic sedimentary deposits (6-12 km total thickness). From a geographical point of view, this region is called the Polish Lowland; it is part of the Middle-European Lowland.



Sketch of the main geological regions of Poland with the locations of health resorts (*) using geothermal springs.

- The Sudetes region, consisting mainly of Pre-Cambrian and Paleozoic formations: it is a sector of the Czech massif, part of which forms the mountain range of the Sudetes, while the rest forms the Fore-Sudetes block. The block is covered by Tertiary and Quaternary formations.
- The Carpathian region, which belongs to the Alpine orogenic system, includes the Outer Carpathians, with Cretaceous-Paleogene flysch formations, and the Inner Carpathians, with Paleozoic crystalline cores and Mesozoic sedimentary formations; the Pieniny Klippen Belt is located between the Inner and Outer Carpathians. This very narrow and elongated ridge, with an extremely complex tectonic structure affected by Mesozoic-Paleogene folding, resulted from the collision of two continental plates. The youngest part of the Carpathians is known as the Carpathian Foredeep, which formed during the Miocene.

Poland is characterized by low to moderate terrestrial heat flow values (30-70 mW/m²), with temperature gradients of between 2° and 3° C/100 m (Sokolowski, 1995). A few dozen warm springs (18°-44° C) are found in the country, in the hilly and mountainous regions of the Sudetes and the Carpathians.

GEOTHERMAL BALNEOLOGY

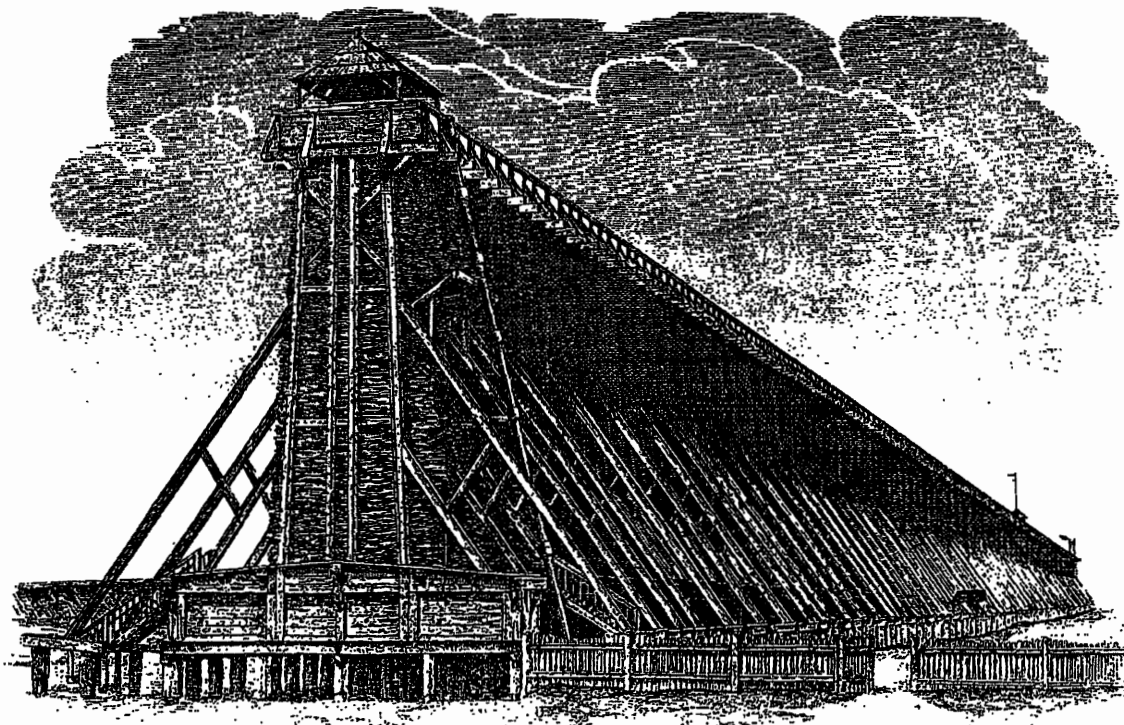
OVER THE PAST 1,000 YEARS, GEOTHERMAL HEAT FROM NATURAL SPRINGS IN POLAND WAS USED only for bathing and balneology at Ciechocinek in the Polish Lowland; Cieplice Śląskie, Łądek Zdrój, and Duszniki Zdrój in the Sudetes; and Iwonicz Zdrój and Zakopane in the Carpathians. Although no evidence has been found proving similar uses in earlier times, it is likely that some of these thermal localities were known and frequented by people for bathing since prehistoric and ancient periods.

CIECHOCINEK (POLISH LOWLAND)

THIS RESORT USED CURATIVE BRINES FLOWING FROM NATURAL SPRINGS OF 10°-13° C. THE HIGH content of chemicals in these spring waters comes from salt-rich Mesozoic formations, which exist at shallow depth in the Ciechocinek area. The salt minerals are dissolved and carried to the surface by water of meteoric origin.

Centuries of use and the excellent healing properties of the warm brines resulted in the mid-19th century drilling of wells to increase the springs' yield. This, in turn, brought about the rapid development of this resort. At the same time, to exploit more efficiently the heat and healing properties of the geothermal brines, modern wooden installations were built near the wells to capture the warm water spray. These structures were designed by Stanislaw Staszic, the "pioneer and father" of Polish geology and mining.

Ciechocinek is situated in Central Poland, on the left side of the Vistula River Valley. Development of the town and its neighborhoods began after the partition of Poland among Austria, Prussia, and Russia in 1772, when Poland lost the Wieliczka salt mine. At that time, by the order of Stanislaw August Poniatowski, king of the remaining Polish nation, brine sources for salt extraction were sought in the Ciechocinek area. In 1823, after the government had bought the brine springs area from private owners, Ciechocinek began to develop rapidly: old brine springs known since the 12th century were restored, new wells were drilled, settling systems were improved, and several salt processing facilities were installed.



Ciechocinek. Wooden installations designed by S. Staszic for spraying warm brines used in curative inhalations. From the mid-19th century. *Mieczkowski, 1873*

From 1836, when the saline springs began to be used systematically for healing purposes, a special therapeutic station was established in the spring area. From 1841 to 1860, the first wells (100- 300 m deep) were drilled. They discharged brines with temperatures of 18° C (Mieczkowski, 1873), about five degrees warmer than the natural spring water. The wooden spraying installations built by Staszic included a number of graduation towers; altogether, these installations were some 2.5 km long (see illustration on prior page). The warm iodine-bromine brines created an ocean-like microclimate, which was especially suitable for natural curative inhalations. At the same time, the infrastructure of the areas around the springs and the wells was improved: embankments protecting the lowland against possible flooding of the Vistula River and a number of other waterworks were built, and a theater was erected (*The Popular Encyclopedia*, 1973).

In 1910, the population was 2,000; however, after Poland regained its independence in 1918 and Ciechocinek was granted civic rights in 1919, the existence of the renowned therapeutic station contributed substantially to the town's development. Thus, Ciechocinek became one of the main Polish resorts: some 60,000 patients were treated there in 1970 and more than 100,000 in 1995.

For present-day treatments, warm iodine-bromine and ferric brines at 30° C are extracted from three wells (1300-1400 m deep), and peat is used for baths. Gynecological diseases, rheumatism, circulation illnesses, problems of the central nervous system, and upper respiratory maladies currently are treated at this resort.

RESORTS IN THE SUDETES

OVER THE CENTURIES, THE SUDETES HAVE BECOME FAMOUS THROUGHOUT CENTRAL EUROPE for beautiful landscapes, a mild climate, and numerous health spas. A number of mineral spring waters have been used for curing purposes, and some have issued thermal waters in use since ancient times. The most important of these springs are Cieplice Slaskie, Ladek Zdroj, and Duszniki.

Cieplice Slaskie. This resort is 6 km southeast of Jelenia Gora, located at about 350 m in the Jelenia Gora Depression, which is surrounded by four mountain ranges: the Karkonoszes to the south (with the highest massif in the Sudetes, Mt. Sniezka, at 1602 m), the Janowickie Rudawys to the east, the Izerys to the west, and the Kaçzawas to the north. In 1785, the population of

Cieplice was 1,391 (*Polish Cities in the Millennium*, 1965), but it grew to 15,500 in 1970, mostly as a result of the geothermal spas.

The Cieplice resort is supplied by warm mineral waters from six springs, which yield 0.2-4 m³/h of water with temperatures of between 20° and 44° C and flow from the Karkonosze mountain granites. Warm waters are used mostly for therapeutic baths; to a lesser degree, however, they are used to treat orthopedic-traumatic and neurological diseases, nephropathies, and urinary tract diseases.

A legend says that the Cieplice warm springs were discovered in 1175 by a Piast prince, a descendent of the Silesian King Boleslaw I the Tall (1127?-1201), when he was chasing a wounded deer. However, the oldest historical record of these springs is found in a document of March 18, 1281. It concerns the donation of *caldius fons* (“warm springs”), along with 250 fieves and a 20-year release from taxation, made by Prince Bernard from Lwówek to the Silesian monastery of Strzegom, which belonged to the Knights of St. John of Jerusalem. This monastery had undertaken the task of curing ill persons through the use of thermal waters.

In 1288, the first curative house was built, and the Czech king authorized the monastery to erect an inn at Cieplice to serve a growing number of patients. The Slavonic name of this locality (*Cieplowody* or *Chleplevode*, which means “warm waters”) can be found in records of Gabriele da Rimini, a papal functionary who visited Silesian villages to collect overdue taxes at the beginning of the 14th century.

In 1381, the resort was purchased by the noble Schaffgotsch family. In 1403, the family founded a prebend of the warm springs on behalf of the Krzeszow Cistercian monastery, established there in 1292. (The monastery received funds from operation of the springs.) After the monastery belongings were liquidated in 1810, the resort was managed directly by the Schaffgotsch family.

The most famous patient who visited Cieplice was Polish Queen Maria d'Arquién Sobieska, in 1687. She came to treat her ailments and to strengthen her poor health and was accompanied by her whole court—some 1,500 people (Kurek and Arczynski, 1970). She was the beloved wife of one of the greatest Polish kings, Jan III Sobieski, whose army heroically helped stop the Turkish invasion in Europe in the famous 1683-battle of Vienna. Two of the warm springs in Cieplice are named after King Sobieski and his wife. A scene of group bathing was painted in



Group bathing in the “Cloister Bath” at the Cieplice Slaskie thermal resort during the 18th century. *Photograph of a picture in the archives of the Cieplice Resort State Company*

the 18th century in the “Cloister Bath,” one of the most important thermal spas in Cieplice Slaskie.

The resort flourished in the 19th century, when additional warm springs were channeled towards the intake system and more modern therapeutic methods were introduced. Towards the end of the century, however, Cieplice faced increasing competition from German and Czech resorts and declined in popularity. The local economy of the town and neighboring areas was reoriented to the machine industry. The Cieplice resort was revived again in 1945. With the warmest curative waters in Poland, it became, and still is, one of the most important spas in Central Europe.

Ladek Zdroj. Ladek Zdroj is located at 440 m on the slopes of the Zlote Mountains, the highest peak of which is Mt. Kowadlo (989 m). This mountain range surrounds the Klodzka Valley from the east, and radioactive and sulfide waters flow from fractured Pre-Cambrian

gneisses. Depending on the season, the flow rate from five springs is 1-17 m³/h, with water temperatures between 20° and 30° C. These warm waters are used mainly for treating patients with motor system, vascular, oral, and dermatological diseases.

The first records of the Ladek Zdroj thermal springs date back to 1242. Ladek was granted civic rights by the Czech crown in 1325, and the first bathing house was built near the end of the 15th century; Ladek continued to develop at a slow but steady pace for about three centuries. At the beginning of the 19th century, the spa began to flourish and the number of patients increased from about 850 per year in 1800 to more than 10,000 per year in 1900 (*Polish Cities in the Millennium*, 1965). Among the most important visitors who stayed at Ladek for treatment were the German poet Johann Wolfgang Goethe; John Quincy Adams, sixth President of the United States; and Russian novelist Ivan Turgenev.

Duszniki Zdroj. This spa is located at 550 m, at the western piedmont of the Klodzka Valley, about 40 km west of Ladek Zdroj. It is supplied with iron- and CO₂-rich warm water from one spring with a temperature of 19°-20° C. The first records date back to 1408. Since then, the water has been used for curative drinking and thermal bathing.

In 1823, the Duszniki resort hosted an outstanding composer: Felix Mendelssohn Bartholdy from Germany. In 1826 Frederic Chopin, the great Polish composer and pianist (1810-1849), stayed at Duszniki for healing treatments. Chopin was only 16 years old when, after finishing secondary school in Warsaw, he went to Duszniki with his mother and sister. Since his early childhood, Chopin had delicate health, suffering from pneumonia. The young pianist's letters provide insight into how he passed the time at Duszniki: "it is the second week of my drinking whey and waters...and, they say, I look better.... In the morning, at six at most, all the patients gather together at the spring, and very poor music...accompanies them in their slow walk..." (Kurek and Arczynski, 1970). During his stay, the young artist gave one of his first public concerts, so arousing the admiration of the audience that their negative impression of the music played by the resort orchestra easily was offset. This was one of the first performances which opened the doors to Chopin's artistic career.

In subsequent years, numerous Poles visited Duszniki (under Czech rule at that time) and built a monument to Chopin, as well as a theater bearing his name. To commemorate the artist and his stay at Duszniki, the warm spring was named *Pieniawa Chopina*, and an international music festival is held there each year.

RESORTS IN THE CARPATHIANS

LIKE THE SUDETES, THE CARPATHIANS ABOUND WITH LOW TEMPERATURE MINERAL SPRINGS, which enabled the establishment of numerous health resorts. But because of the different geological structure and hydrogeological conditions of the two regions, the Carpathians have relatively fewer geothermal springs, which are located in two areas: Iwonicz and Zakopane (see second map). These springs have been known and used by local people for many centuries.

Iwonicz Zdroj. This resort is situated at about 410 m, on the foothills of the Beskid Niski Highlands, one of the Carpathian chains. Records of warm springs usage date back to 1578 and 1630 (*Polish Cities in the Millennium*, 1965), when they were recognized and described by the royal physicians. However, it wasn't until 1793 that the resort started to flourish, after facilities were built to encourage more people to take advantage of thermal balneology and mineral water cures.

At the beginning of the 19th century, reputable chemists and physicians voiced favorable opinions about the high curative value of these waters. In particular, in 1856, Jozef Dietel, a professor at Jagiellonian University, declared Iwonicz the "prince of iodine waters." Since then, Iwonicz waters have been bottled and widely sold in Central Europe.

To increase the production of the iodine-rich warm waters, some wells (400-600 m deep) were drilled in this area around the start of the 20th century. The warm brine discharged by one of these wells drilled in 1911 is still used for cures today. Due to water production from the wells, however, the natural springs started to dry up. Water production was subsequently moved to the wells only. Today, warm water for curing purposes is taken from nonproducing oil wells.

The interwar period (1918-1939) was a real boom for this spa. Afterwards, following a decline which lasted some 20 years, Iwonicz again flourished in the late 1950s. It thus became, and still is, one of the best known Polish resorts. Twelve wells, with a maximum depth of 1000 m, produce warm water ($T=20^{\circ}\text{C}$, and $\text{TDS} = 6\text{-}19\text{ g/l}$) from Eocene sandstones. The water is especially rich in bromine, iodine, boron, and free carbon dioxide. Rheumatism, diseases of the motor, alimentary, and respiratory systems, dermatological diseases, and many other illnesses are treated at this spa. The water is also used for drinking, for the preparation of peat baths (mud or "fango" therapy), and the extraction of salts for the cosmetic industry (Karwan, 1989).

Zakopane. Zakopane is located in Southern Poland, on the northern slopes of the Tatra Mountains, the highest sector of the Carpathians. These are the only Polish mountains involved in the Alpine orogenesis; the highest peak is Mt. Rysy (2499 m). The Tatras region, in particular Zakopane and the nearby Podhale area, constitutes the main centers for tourism and winter sports in Poland. Their popularity started in the second half of the 19th century and continued to grow until the present time. With a population of about 30,000 inhabitants, this region is visited now by 3.5 to 4 million tourists each year.

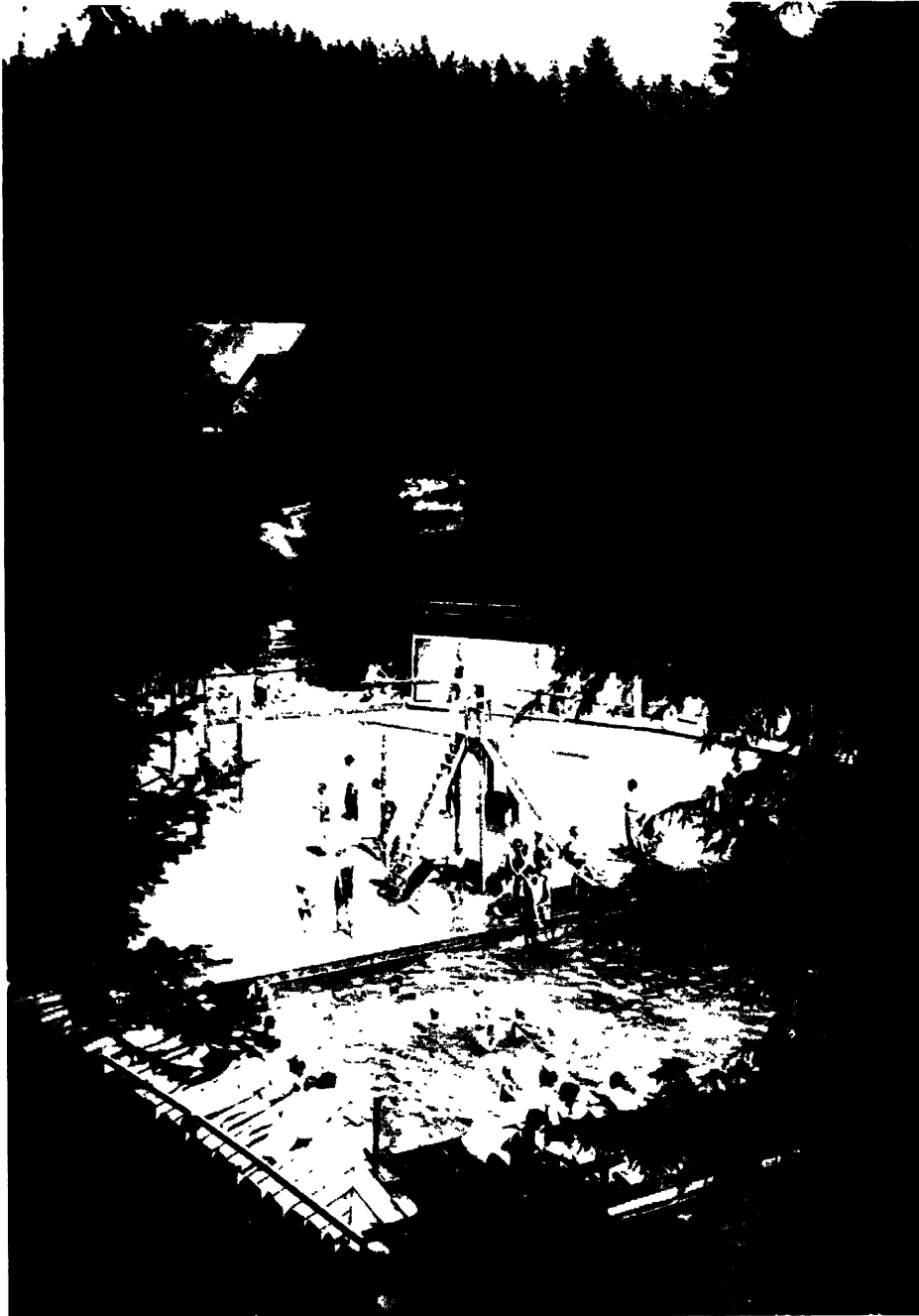
In addition to the scenic attractions, a restorative summer climate, and winter ski facilities, a significant contribution to tourist development in Zakopane and Podhale is the exploitation of geothermal waters. In the region of Podhale in the town of Zakopane, a large-scale district heating system has been under construction since the end of the 1980s. Started as the first system of its type in Poland, it will be accompanied by other geothermal uses. Thermal bathing, however, began many centuries ago at Jaszczurowka (a borough of Zakopane), where a warm spring (20° C) was used by local highlanders. The spring was in existence until the late 1960s. Due to a salamander species (*salamandra salamandra*) that found its optimum habitat in the wet area around the warm pool, the spring was named *jaszczur*, which means “reptile” (Radwanska-Paryska and Paryski, 1973).

The spring was first described scientifically in 1844 by L. Zejszner, an outstanding geologist, forerunner of the geological investigations in the Tatra Mountains. He wrote: “not a trace of an igneous process will be found in the neighborhood [of the spring].... The spring is located in correspondence to sedimentary rocks....” Therefore, Zejszner concluded, the water derived its temperature from depth. From the hydrogeological point of view, Zejszner correctly stated that the spring was the result of an ascensional water circuit that reached the surface and outflowed through an open segment of the regional fault marking the limit of the northern border of the Tatras ridge.

Other scientists and medical doctors in the mid-19th century studied the spring water’s chemical and therapeutic properties. They recognized that the Jaszczurowka warm water was particularly suitable for curing dermatological, rheumatic, and endocrinological diseases, as well as treating patients with contagious diseases, such as leprosy.

This spring was easily noticed because “in winter, the place is constantly steaming, and even during very severe winter days, fresh grass keeps on growing...” (*Geographical Dictionary of*

the Polish Kingdom and Other Slavonic Countries, 1882). This same source also reports that long before the 19th century the local highlanders soaked “the diseased parts [of their bodies] in the warm water for hours, six hours or more, without interruption.... It usually sufficed to take one such bath to alleviate ailments....” The first investigators of the Jaszczurowka spring



The Jaszczurowka spa near Zakopane: general view of the bathing place using geothermal water (20° C), with the wooden pier (“sunny beach”) and related facilities, as seen at the beginning of the 20th century. *Photo by Z. Sulkowski; reprinted by R. Bukowski from the collection of Tytus Chalubinski Tatra Museum in Zakopane*

also observed that it was one of the few warm springs in the Polish territory to have such efficacious healing properties.

In 1862, the owner of the spring's site constructed a small bathing facility (Zwolinski, 1966). The spring was timbered, with a perforated floor added for water outflow. Next to the pool, modest wooden buildings were constructed as dressing rooms, and an inn was built nearby. Thus, the owner could charge the users for bathing.

Since the warm spring and the bathing facilities were located in a beautiful spot, among fir trees at the foothills of the Tatra Mountains, an increasing number of tourists began visiting the site (Radzikowski, 1870). Towards the end of the 19th century, the Polish sector of the Tatra Mountains and the village of Zakopane were "discovered" by Dr. Tytus Chalubinski, a well known personality in Poland; consequently, many representatives of Polish high society frequented Zakopane.

Exceptional natural beauty and the highlanders' rich folk culture attracted many other people of elite society, as well as artists and scientists. Mountain tourism flourished, and sports and recreational activities became fashionable. Moreover, due to the fresh summer climate and the



The Tatra Mountains with the characteristic peak Giewont (~1900 m) in the background. The Zakopane resort and geothermal bathing facilities are located in this beautiful sector of the Tatras. *Photo by M. Kowalski, 1996*

therapeutic characteristics of the thermal water, treatments for lung and respiratory diseases were especially sought at Zakopane, and mineral water cures became more popular as well. The facilities at Jaszczurowka thus became a curing and social “must” for the many tourists who visited the Zakopane area from 1880-1900.

This is evidenced by numerous written records of that period: “in summer visitors coming to Zakopane are used to enjoying baths...” (*Geographical Dictionary of the Polish Kingdom and Other Slavonic Countries*, 1882), and Walery Eljasz Radzikowski, author of the first tourist guide to the Tatra Mountains, wrote in 1870: “it is hard to get a bath before noon; ...much time must one wait for taking a bath, otherwise, as it often happens, one has to return home without having had any bath....”

The Jaszczurowka spring is recognized in Polish literature and folk culture. A beautiful poetic description of the place can be read in Stanislaw Witkiewicz’s novel *At the Mountain Saddle* (1891). The enchantment created by the beauty of the Tatra Mountains and the extraordinary abundance and originality of the highlanders’ culture are described eloquently. The author was the father of Stanislaw Ignacy Witkiewicz (Witkacy): a world-renowned playwright, art critic, philosopher, painter, and forerunner of the Theater of the Absurd. In describing the spring, Stanislaw Witkiewicz also quoted some of the tales related to Jaszczurowka. In particular, he recalled “Sabala,” the most famous Tatra storyteller, singer, gifted violinist (and poacher as well!), who had described the Jaszczurowka spring in previous years.

A passage from Witkiewicz’s novel reads, “By coach or on foot, from the very early morning hours, crowds of people are going to the emerald warm spring at Jaszczurowka. Closed in a pool made of fresh fir timber, the spring resembles light sapphire set in pale gold. The bathing people loom as greenish *jaszczur* (‘reptiles’): naturally I am speaking of men only! The spring, surrounded by bushes of marsh-marigold and coltsfoot, flows out at the boundary of a ravine like a little mountain stream.... Jaszczurowka is romantic: not only for its warm, light blue and unique spring, but also for the black-orange spotted and clumsy salamanders living there. After thirty years of peaceful life, the salamanders inflate their bodies enormously and become ‘dragons.’ Due to this change, the ‘reptiles’ become equipped with a number of heads and gain a terrible hunger. Bones of these ‘dragoned’ reptiles can be found, according to ‘Sabala,’ in many caves and recesses. However, not only for its ‘dragons’ is Jaszczurowka so romantic; it is for its people who extol the beauty of their spring in a poem, whose refrain says: ‘Oh, sweet, bright, and transparent waters; with the mirror wave....’”

Between the world wars (about 1919-1938), Jaszczurowka continued to flourish and reached its peak in balneological attendance. Next to the spring pools, a wooden pier was built (the “beach”) where people used to rest and sunbathe. Swimming competitions and water-polo matches with a great number of competitors and fans were organized.

Two pools supplied by the Jaszczurowka spring remained in use after the end of World War II until the 1960s. There were also plans to modernize the curing establishment and organize new balneological and therapeutic treatments. After drilling a well to raise the spring’s output, however, the hydrogeologic circuit was drowned and the warm spring disappeared, due to cold water drawn in from the neighboring stream. Consequently, all plans to increase balneotherapeutic activity were deferred temporarily.

However, to revitalize and further develop the geothermal bathing tradition of the Zakopane region while expanding the use of the Earth’s heat for other purposes, new initiatives were begun at the end of the 1960s. A modern geothermal bathing establishment was erected in the center of Zakopane (see prior photograph); it is supplied with warm waters (26°-36° C) from two wells and is frequented, especially in summer, not only by Poles but by many foreign tourists. In addition to this spa, a large-scale geothermal district heating project was begun recently in the nearby Podhale area to replace the polluting coal heating system with clean, natural heat.

CONCLUDING REMARKS

POLAND AS A WHOLE IS CHARACTERIZED BY LOW TO MODERATE TERRESTRIAL HEAT FLOW values, and the country has three geological areas with thermal springs at temperatures of between 18° and 44° C. Considering the severe climatic conditions of Polish winters, prehistoric and early historic people very likely took advantage of the natural heat that was responsible for relatively mild and constant temperatures in the caves where they settled in the Wielun-Kraków area and in the Swietokrzyskie (“Holy-Cross”) Mountains. While it is also likely that these people knew and used the water from some of these thermal springs, no evidence has been discovered within the Polish territory to support this hypothesis.

The first written records describing the use of geothermal waters for balneotherapy date back to the 12th century and provide evidence that the practice of thermal bathing has old roots in

Poland. Warm springs were used in the Sudetes and the Carpathians, as well as at Ciechocinek in the Polish Lowland. While undergoing flourishing and recessive periods, this practice developed to the point that some of the Polish geothermal sites (e.g., Cieplice, Duszniki, and Iwonicz) became renowned spas in Central Europe, similar to those of Karlove Vary in the Czech Republic. The benefits of these spas were experienced by famous personalities in Polish and international artistic society, such as Frederic Chopin at Duszniki. In a few cases, the occurrence of thermal springs spawned folk legends about the warm water sources.

The tradition of geothermal balneology and bathing has grown in Poland for the past 1,000 years, providing the foundation of recent geothermal resource development. This development, however, is limited to a few locations and is based on warm waters issuing from natural springs, which are limited in quantity and temperature. In most cases, therefore, natural heat will be tapped in the future by wells drilled to 1-3 km deep. This is happening in the Podhale region and in other parts of the Carpathians, as well as in the Polish Lowland. Here geothermal resources will be used for integrated applications: domestic heating, industrial processes, greenhouses, fish farming, and balneology.

ACKNOWLEDGMENTS

THE AUTHORS ARE INDEBTED TO THE EMPLOYEES OF THE TYTUS CHALUBINSKI TATRA MUSEUM IN Zakopane: to Mrs. A. Liscar and Mr. J. Darowski for their help in preparing the source material related to the Jaszczurowka spring, to Mr. J. Filar from the High Tatras Company, and to Mr. M. Kowalski for photographs of the bathing place in Zakopane. Thanks are also due to Mrs. T. Kepinska and Mr. J. Kepinski for their assistance in archival investigations and preparation of the figures. The authors are also grateful to Mrs. W. Fortuna from the Cieplice Resort and to Professor W. Ciekowski (Wroclaw University) for providing the figures from the Sudetes region and for their kind permission to publish them in this chapter. The authors express their special gratitude to Dr. R. Cataldi for his valuable contribution to the final content and form of the chapter.

CITED AND SELECTED REFERENCES

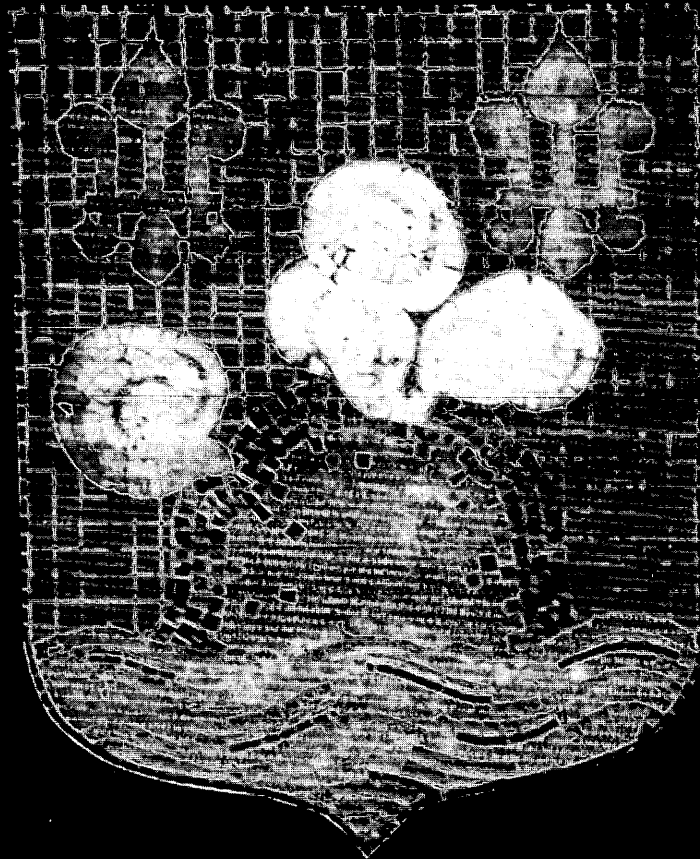
- Ciezkowski, W. 1992. *Ladek spa (Ladek Zdroj)*. Oficyna Wydawnicza Sudety, Wrocław. (In Polish).
- Geographical dictionary of the Polish Kingdom and other Slavonic countries (Słownik geograficzny Królestwa Polskiego i innych krajów słowiańskich)*, vol. 3. 1882. F. Sulimierski, B. Chlebowski, and W. Walewski, eds. Warsaw. (In Polish).
- Karwan, K. 1989. *Mineral and therapeutic waters of the Carpathian health resorts (Wody mineralne i lecznicze uzdrowisk karpackich)*. Academy of Mining and Metallurgy Publishers, Kraków. (In Polish).
- Kulik, Z. 1986. *Jelenia Góra and vicinity. A guide (Jelenia Góra i okolice)*. Sport and Turystyka Publishers, Warsaw. (In Polish).
- Kurek, T. and S. Arczynski. 1970. *Lower Silesia (Dolny Śląsk)*. Sport and Turystyka Publishers, Warsaw. (In Polish).
- Mieczkowski, L. 1873. *The historical and therapeutic aspects of Ciechocinek (Ciechocinek pod względem historycznym i leczniczym)*. Warsaw. (In Polish).
- Polish cities in the millennium (Miasta polskie w tysiącleciu)*, vol. 1. 1965. The Ossolineum Publisher, Wrocław-Warsaw-Kraków. (In Polish).
- The popular encyclopedia (Encyklopedia powszechna)*. 1973. Polish Scientific Publishers, Warsaw. (In Polish).
- Radwanska-Paryska, Z. and W. H. Paryski. 1973. *Encyclopedia of the Tatra Mountains (Encyklopedia tatrzańska)*. Sport and Turystyka Publishers, Warsaw. (In Polish).
- Radzikowski, W. E. 1870. *New illustrated guide to the Tatra and Pieniny Mountains (Nowy ilustrowany przewodnik do Tatr i Pienin)*. J. K. Zuparski, ed. Poznan. (In Polish).
- Sokolowski, J., J. Sokolowska, S. Plewa, S. Nagy, M. Krokoszynska, and U. Krzysiek. 1995. *Geothermal provinces and basins in Poland*. MEERC PAS Publishers, Kraków.
- Witkiewicz, S. 1891. *At the mountain saddle—Impressions and pictures from the Tatras (Na przełęczy—Wrażenia i obrazy z Tatr)*. Gebethner and Wolf Publishers, Warsaw. (In Polish).
- Zejszner, L. 1844. *On the temperature of the Tatras' and adjacent areas' springs (O temperaturze źródeł Tatrowych i pasm przyległych)*. Biblioteka Warszawska, t.2, Warsaw. (In Polish).
- Zwolinski, T. 1966. *The Tatras. A guide (Tatry. Przewodnik)*. 12th ed. Sport i Turystyka Publishers, Warsaw. (In Polish).

The Authors:

Julian Sokolowski
Polish Academy of Sciences
Mineral and Energy Economy Research
Institute
Polish Geothermal Association
Ul. J. Wybickiego 7, 31-261 Kraków,
Poland
Telephone/Fax: 48.12.632.24.35
E-mail: pga@min.pan.krakow.pl

Jozefa Sokolowska
Polish Geothermal Association
Ul. J. Wybickiego 7, 31-261
Kraków, Poland
Telephone/Fax: 48.12.632.24.35
E-mail: pga@min.pan.krakow.pl

Beata Kepinska
Polish Academy of Sciences
Mineral and Energy Economy Research
Institute
Geothermal Laboratory Banska Nizna
Polish Geothermal Association
34-424 Szaflary, Poland
Telephone/Fax: 48.12.73.218
E-mail: labgeo@zakopane.top.pl



Shield of the town of Chaudes-Aigues, France, in Southern Auvergne. The design in colored mosaic tile depicts a volcano releasing plumes of whitish steam while surrounded by undulating waves of hot water. In the Late Middle Ages, the town began a system of heating private homes and public buildings with geothermal water. The heating system, modernized and expanded, continues today.
