INTERNATIONAL SUMMER SCHOOL
on Direct Application of Geothermal Energy
Under the auspice of:
Division of Earth Sciences
ЗЕМАК
IGA
GtV

Chapter 1.6

THERMAL SPRINGS AND SPAS IN POLAND

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Summary

Geothermal waters from springs and wells are currently used in eight spas and water centres in Poland. These resorts have long and interesting history, being important part among all health spas in the country. The demand for geothermal curative and recreation services offered in spas constantly increases. The paper presents several cases of geothermal resorts and some examples of initiated and planned new projects which will be often executed as a part of complex systems of geothermal energy application both for space heating and curative purposes. In several places there are prospects to construct new geothermal resorts to be based on warm waters supplied by wells. Balneo-therapy and bathing using natural warm waters constitute prospective sector of geothermal activities and business in Poland.

Key words: geothermal waters, balneo-therapy, bathing, Poland

1. INTRODUCTION

The tradition of use of geothermal waters for bathing and balneo-therapy has old roots in Poland. The first written records report that since the 12th century warm spring waters have been used for balneo-therapy in some localities. Through the centuries, warm springs were used in the Sudetes and Carpathians Mts. Yet undergoing up- and down-periods, this practise developed rather much in time, to the point that some stations (Cieplice, Duszniki, Iwonicz) became quite renown spas in Central Europe. With time, several other spas using geothermal waters have been founded which are still in operation (Sokolowski et al. 1999).

With such a background, the country is still at the very beginning of geothermal application for space heating and other agricultural and industrial uses; such activities date back to the 1980s only. In 2001 three geothermal space-heating plants were online: in the Podhale region, in Pyrzyce town and in Mszczonow town (Kepinska et al. 2000). Several other feasibility studies and utilisation projects are in progress. Most of the project already under construction and planned provide the use of the geothermal waters for the recreation and therapeutics besides their heat application.

In the recent years the growth of the interest in recreation and water centres development, as well as water therapeutics including the geothermal water application have appeared in Poland. It concerns the operational spas as well as – it‘s worth a notice – the localities, which have never

dealt in this field and they plan to develop that activity from the very beginning using the geothermal water discharged by existing or planned wells. That sector of the recreation and therapeutics, which has great prospects of development and economic attraction.

The demand for the geothermal curative services is great and still grows. The spas carry out the modernisation of the facilities and upgrade their service despite the financial and legal difficulties resulting from the change of the ownership and financing rules of the spa enterprises and fees for stay and service as well. Many spas develop prosperously achieving the proper European standards.

2. GEOTHERMAL RESOURCES

Poland possesses large low-enthalpy geothermal resources to be found within ca. 80% of its territory (Sokolowski 1995). They are connected with extensive geothermal provinces predominantly built of sedimentary basins with numerous geothermal aquifers (Fig. 1) which are as follows:

- *The Polish Lowland Province.* It forms the most extensive and prospec-tive unit containing numerous geothermal aquifers (Palaeozoic-Cretaceous). The reservoir temperatures range from 30 to 130^{o}C (1-3 km of depth). The TDS range from 1 to 300 g/l.
- *The Fore-Carpathian Province.* Geothermal aquifers occur in Mesozoic-Tertiary rocks. The reservoir temperatures range from 25 to 50^{o}C, while the TDS is variable, from several to ca. 100 g/l.
- *The Carpathian Province.* Geothermal aquifers are connected with Mesozoic-Tertiary formations. The TDS range from 0.1 to ca. 100 g/l.
- *The Sudetes Region.* It is characterized by limited possibility of geothermal aquifers' occurence in fractured Precambrian and Palaeozoic crystallinic rocks.

Considering the present prices of traditional fuels, feasible geothermal plants can be built in ca. 40% of Poland (Kepinska et al. 2000). The most favourable reservoir conditions exist in the Polish Lowland (Sokolowski 1993, 1995; Gorecki 1995, 1998; Ney 1995) and in the Podhale region (Kepinska 2000).

3. GEOTHERMAL BALNEO-THERAPHY AND BATHING

3.1. Generals

In Poland there are 36 spas applying underground waters for balneology and bathing. Among them eight spas use 20 - 62^{o}C geothermal waters (Fig. 1) issued by natural springs or discharged by wells. Usually, both cold and warm waters are applied. Main information on localities using geothermal waters for bathing and curing is given in Table 1.

Polish spas (including the geothermal ones) act according to legal regulation concerning spas and balneology, which was adopted in 1966 and updated in 1990. At present (2001) it is expected to pass a new law. The spa localities hope for prosperous sustainable economic development resulting from recreation and balneology. It is expressed by establishing many so called spa boroughs within the entire country. It may be sentenced that there is a boom in the production of mineral water in many spas and their sale on both the country market and abroad. The development of balneology and spa services in Poland requires supporting state and self-government policy. Among others, the Economic Chamber – Polish Spas was created for that purpose. It concentrates companies and institutions dealing in spas. Its main task consists in representing spas' interests against home and foreign bodies, acting for the development of the existing spas and establishing new ones, participation in legislative works, promotion, and the elaboration of the spa standards. The necessity of the adjustment of the spa service to European standards is noticeable. The role of the local self-government in spa management, as well as the other activities serving the sustainable development of such localities should be emphasised.

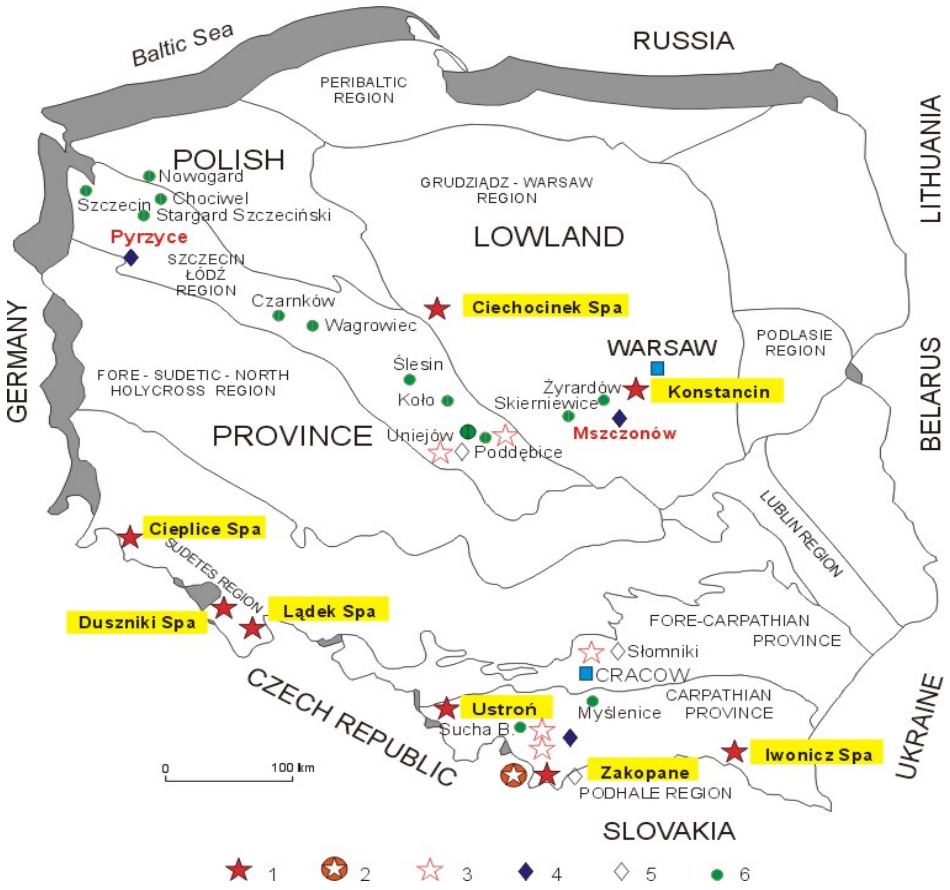

Fig. 1. Geothermal spas in Poland (geothermal division based on Sokolowski 1995)

Geothermal spas and water centres: 1. on-line, 2. under construction, 3 – planned to construct.
Geothermal space heating plants: 4. on-line, 5. under construction, 6. planned to construct

Table 1. Polish spas using geothermal water for bathing and balneo-therapy (based on Kepinska et al. 2000)

Locality	Type of water intake	Maximum utilisation			Annual utilisation	
		Flowrate kg/s	Temperature,°C		Average flowrate kg/s	Energy use[b)] TJ/yr
			Inlet	Outlet		
Zakopane	w	36	26-36	25	18	14
Cieplice Spa	s + w	7.5	36-39[a)]	26	6.0	10
Ladek Spa	s + w	11	20-28 s 44w	20	10.8	16.8
Duszniki Spa	s + w	5.5	19-21	19-21	5.5	0.3
Ciechocinek Spa	s + w	56.8	27-29	20	4.2	2.8
Konstancin	w	2.5	29	12	0.1	0.2
Ustron	w	0.9	28	11	0.4	0.58
Iwonicz Spa	s + w	3	21	10	0.4	0.58

w – well, s – spring, [a)] mixture of 20-62°C waters from springs and wells (20-62°C),
[b)] energy use (TJ/yr) = Annual average water flowrate (kg/s) x [Inlet temp.(°C) - Outlet temp.(°C)] x 0.1319

3.2. Geothermal spas – selected cases

The oldest spas in Poland are located in the Sudetes Mts. (SW-Poland). During the centuries, that region has been famous throughout Central Europe for its landscape and numerous health spas. Abundant mineral springs have been used there for healing purposes. Some of them issue geothermal water that contributed to the flourishing of certain resorts like Cieplice Spa, Ladek Spa and Duszniki Spa. In the Polish Lowland in two localities: Ciechocinek and Konstancin cold and geothermal waters produced by the wells are used for curing and recreation. Three resorts using geothermal waters for described type of application are situated in the Carpathian Mts. (S-Poland): Iwonicz Spa, Ustron and Zakopane. This region abounds with the low temperature mineral springs, which gave rise to numerous health resorts. The most famous among them are Krynica and Szczawnica. On the contrary, warm springs are very rare there and were known in Iwonicz and Zakopane only (Fig. 1), while at present geothermal balneo-therapeutical and water centres are based on water supplied by the wells.
To give insight into geothermal spas and water centres in Poland, some selected cases are presented in this chapter.

Cieplice Spa

Having the warmest curative waters in Poland, Cieplice (Fig. 1) is one of the most famous and visited spas in Poland. Its convenient location close to the frontier attracts patient and tourists from the neighbouring countries – Czech Republik and Germany. Natural outflows of warm waters were known there in the 13th century already when they started to be applied for curing (Sokolowski et al. 1999). The spa of European renown already operated in the 17-19th centuries.

Geothermal aquifers occur within fractured Carboniferous granites of the Karkonosze Mts. massif.

Currently, water flows out from several natural springs and one well. The springs yield ca. 10 m^3/h of water with temperatures ranging from ca. 20 to 44°C. The well (750 m of depth) is capable to discharge 40 m^3/h of water with wellhead temperature of 60-68°C (Dowgiallo 1976; Dowgiallo & Fistek 1998). The total dissolved solids (TDS) are ca. 600 – 700 mg/l (exceptionally up to 1000 g/l), predominant water type being SO_4 – HCO_3 – Na + F + Si. The content of H_2SiO_3 amounts to 100 mg/l and is the highest among all geothermal waters in Poland, very high is also the content of fluorine F ion – up to 12 mg/l (Dowgiallo 1976).

Waters are predominantly suitable for therapeutic baths; and they are also used for other treatments, such as orthopaedic-traumatic and neurological diseases, nephropathy and the diseases of the urinary track. The spa offers a wide range of the curative treatment and physical recovery. Mineral waters are also bottled.

The oldest historical record of Cieplice comes from 1281. It was found in a document concerning the donation of "Caldius Fons" (warm springs) to the Silesian monastery of the Knights of St. John of Jerusalem from Strzegom by prince Bernard from Lwowek. In 1288 the first curative house was built and consent was given to erect an inn for the growing number of patients. The Slavonic name *Cieplowod y*- "*Chleplevode*" (warm waters) can be found in records of the papal functionary Gabriele da Rimini who visited the Silesian villages to collect the overdue taxes.

In the past centuries, the most magnificent patient who visited Cieplice was the Polish queen Maria d'Arquien Sobieska who came there in 1687. The queen was accompanied by her numerous court, some 1500 people. She was the beloved wife of one of the greatest Polish kings Ian III Sobieski whose army stopped the Turkish invasion in Europe in the famous battle of Vienna in 1683. Two of the warm springs in Cieplice were named after king Sobieski and his wife.

In the end of the 1990s, the other existing well in Cieplice was deepened from 661 m to 2002 m. The self-outflow of ca. 90 m^3/h water with wellhead temperature of 87,9°C was obtained, while the measured bottom temperature (depth of 1870 m) was 97,7°C (Dowgiallo 2000). Those

works were carried out in the response to the growing demand for curative water, planning the sport and recreation facilities, and the project of utilisation of the water for heating. Currently (2001) the well is being tested. Starting of the utilisation projects depends on obtaining the proper founds.

Ladek Spa

The first records of warm waters in Ladek come from 1242. The first bathing house was built towards the end of the 15th century - since then it developed slowly but flourished in the 19th century. Among numerous visitors who stayed at Ladek for curing, was John Quincy Adams, the sixth President of the United States. He declared at the end of his visit in Ladek: "I have never seen a spa, the location and appearance of which would be as much favourable to health preservation and restoring as Ladek".

Geothermal waters occur in the fractured Pre-Cambrian gneisses. The flowrate from several springs amounts 1 - 17 m^3/h, with the temperature in the range from 20 and 30°C. There are also two wells (up to 700 m) discharging water with wellhead temperature ca. 46°C. The TDS is low: 160 – 280 mg/l, but with high content of fluorine ion F (up to 11 mg/l) and $HSiO_3$ (up 70 mg/l). Radioactive waters harnessed at Ladek Spa are suitable mainly for treating patients with the motor system, vascular, oral and dermatological diseases.

Among Polish resorts, Ladek Spa possesses one of the greatest therapeutic bases. Wide promotion and advertising of the spa also addressed to the foreign clients, particularly from Czech Republic and Germany is conducted. The cultural performances are organised and sponsored. A system of preferences and rebates was introduced. Some interesting offers for investors were prepared. Ladek is a good example of proper joint utilisation of the geothermal water in curing, recreation, and tourism. It is a town, which offers not only curing services, but also variety of rest, health preventive treatment and physical recovery.

Duszniki Spa

Duszniki Spa is located about 40 km west from Ladek Spa. The first records on warm springs from Duszniki come from the year 1408 already.

Geothermal aquifers are connected with the Pre-Cambrian shists formation. Currently, geothermal waters are produced under artesian conditions from several shallow (up to 160 m) wells. The wellhead temperatures are 17 - 18°C. These relatively low temperatures result from the fact that waters are cooled down on the way to the surface due to expansion of dissolved CO_2. There exists also one spring named *Pieniawa Chopina*. Geothermal waters from Duszniki represent the type HCO_3 – Ca – Na – Mg. They are rich in iron, CO_2 (up to 2 g/l) and $HSiO_3$ (50 – 90 mg/l). The TDS amounts ca. 2 g/l (Dowgiallo 1976).

Duszniki Spa is famous thanks to Fryderyk Chopin - the great Polish composer and pianist (1810 - 1849) who stayed there for a healing treatment in 1826. He was only sixteen when he came to the resort along with his mother and sister. During his stay in Duszniki the young artist gave one of his first public concerts raising sincere admiration of the audience. This was one of the first performances, which opened the gateway to the world's artistic career to Chopin (Sokolowski et al. 1999).

In the 19th century Duszniki, then belonging to the Czechia, was visited by numerous Poles who had founded a monument of Chopin and a theatre bearing his name. To commemorate of genius artist and his stay in Duszniki, the warm spring was given the name „*Pieniawa Chopina*". It is also worth noting that each year Chopin international music festivals are organised in Duszniki – the oldest one in Poland, gathering outstanding musicians and numerous international audiences.

In Duszniki there are some medicine research units, which are managed by country universities of medicine. They deal with balneo-therapeutics. The spa makes a wide policy of its development, namely: expansion and modernisation of recreation and tourism infrastructure,

sustainable development, Chopin Festival of Music, promotion and advertising, co-operation with other spas in this region, joint promotion of the curing advantages, offers for investors.

Ciechocinek

Ciechocinek is situated in the Central Poland, on the left bank of the Vistula River Valley (Fig. 1). As a health resort, it started to develop at the beginning of 19th century on the base of curative brines with the temperatures of 10-13°C outflowing from natural springs.

Geothermal aquifers are found in the Jurassic sandstones. Currently the spa is supplied with cold and geothermal water discharging by several wells. Warm waters are tapped by two wells (depths of ca. 1300 m and 1380 m) which produce 29 - 37°C waters. The TDS is variable: 3 – 72 g/l depending on the depth of the aquifer. Waters predominantly represent Cl – Na + F + Br + J +B + (SO_4 + H_2S) type (Krawiec 1999).

The content of iodine and bromine comes from the Zechstein salt formations. The salt minerals are dissolved by waters of probably paleoinfiltration meteoric origin.

For curative treatment there are used both warm iodine-bromine brines, cold waters, and peat for highly active peat baths. Patients with gynaecological diseases, rheumatism as well as those having problems with circulation, central nervous system and upper airways can be treated in this resort. The curing consists in hospital, sanatorium, or part-time treatment. Along with water exploitation for curing and bathing, the production of table salt (with iodine content), some kinds of mineral water, lye and crystalline slime have been carried out.

The development of the town and its neighbourhood commenced after the first partition in 1772 when central Poland lost the access to the Wieliczka salt mine. At that time, brine sources for salt extraction were sought for there (Sokolowski et al. 1999).

In 1836 the saline springs started to be used also for healing purposes. In mid 19th century a specialist therapeutic station was established in the spring area. In 1841-1860 the first shallow wells were drilled. They discharged brines with the temperatures in the range of 18°C. According to the project of S. Staszic – the pioneer of Polish geology and mining - specific wooden installations (2.5 km long) remaining the graduation towers were built: they were used for spraying iodine-bromine brines. In such a way, an ocean-like microclimate was created, especially suitable for natural curative inhalations. These installations have been in use so far.

After Ciechocinek was granted civic rights (1919), the therapeutic station was a starting point for a rapid development of the city. Then already about 25 000 person per year cured in Ciechocinek.

At present Ciechocinek is one of the main Polish resorts. A number of cured persons exceeds 30 000 per year. After financial problems in the beginning of 1990 were solved, Ciechocinek again came in the development period. Following items make success and renown of the spa:

- Variety and high quality of curing service,
- Production of curing means in a wide range,
- Spa facilities strictly satisfying the requirements of curing people.
- High quality and volume of the accommodation and food base (19 sanatoriums, 8 spa hospitals, numerous lodging houses, restaurants, bars etc.),
- Excellent urban layout of the spa – four spa parks, gardens, nature reserves,
- Wide promotion and advertisement.

Iwonicz Spa

Iwonicz Spa is located in the Outer Flysch Carpathians (Fig. 1). Geothermal waters (ca 20°C) occur within the Eocene sandstones and are currently produced by several post-extraction oil wells (to 1000 m of depth). The TDS values vary from ca. 8 to 20 g/l. The brines represent the type Cl - HCO_3 – Na + Br + J + (CO_2 + H_2S). Because of their origin, the water reserves are non-renewable thus must be exploited with special care.

Rheumatism, skin diseases, diseases of the motor, alimentary and respiratory systems, and many other illnesses are treated in this resort. Waters are used for drinking and bathing treatments (peat baths including), and also for curative and cosmetic salt extraction.

The first records of the use of warm springs in this locality date back to 1578 and 1630, when they were recognised and described by the royal physicians. The first bathrooms were built in 1793 and the resort soon started to flourish. At the beginning of the 19th century outstanding chemists and physicians granted favourable opinions about the high curative value of these waters. It was at the same time that suitable utilities and objects for curative purposes were built. Some of them have survived till the present. In 1856 Jozef Dietel - professor of the Jagiellonian University, called Iwonicz a „prince of iodine waters". Iwonicz water was bottled and sent around the Europe. First wells (400 - 600 m deep) supporting the existing springs were drilled at the end of the 19th century. Warm brine discharged by one of them has been used till now. With time, the former springs vanished, so as the exploitation started from the post-extraction oil wells (Sokolowski et al. 1999).

The interwar period was a real boom for Iwonicz. Also at present this is one of the best known and most frequented Polish resorts. At present over 30 000 patients and tourists per year visit Iwonicz Spa.

4. FURTHER PROJECTS

Besides already existing structures, there are plans to build new geothermal health and recreation spas. Some projects await realisation, several ones are in progress of designing. The popularity of so called water centres, several of which have already been successful, raises the interest to build more such facilities. In general, the centres will be one of the elements of integrated or cascaded geothermal systems. They are designed to use waters from deep and shallow wells, or thermal energy stored in shallow ground horizons, often with additional use of heat pumps and other renewables (i.e. solar). They include, among others, a geothermal station under construction in Zakopane, as well as several others planned to be realized (i.e. Poddebice).

Zakopane and Podhale region

Zakopane is located in the southern Poland (Fig. 1, Fig. 2) on the slopes of the Tatra Mts. (the highest part of the Carpathians). The Tatras, Zakopane and the Podhale region, due to their natural characteristics, constitue the main centre of tourism and winter sports in Poland. Over 3 million tourists visit this place each year. In the last years a construction of a large-scale district heating system and other types of direct geothermal utilization started to be carried out there (Kepinska et al. 2000) including balneo-therapy and bathing, because there is a great demand for water and geothermal centres.

The main geothermal artesian aquifer occurs in the Eocene and Mesozoic carbonates (depths of 1-3.5 km). The reservoir temperatures reach up to 80-100^{o}C; flowrate from a single well 55-150 l/s; TDS of 0.1-3 g/l; wellhead static pressure 27 bar. Over ten geothermal wells have been drilled within this area so far. All of them issue waters which have curative properties suitable in the dermatological, rheumatic, and endocrinological diseases; apart from this, they can be used as an adjunctive treatment in patients with contagious diseases.

The tradition of using warm waters for bathing is connected with Jaszczurowka – a suburb of Zakopane. A 20°C natural spring existing there was scientifically described in 1844. Hydrogeologically, this was an ascension spring outflowing along the regional fault which delineates the northern border of the Tatra Mts. The warm spring in Jaszczurowka had been used by the local highlanders long before the middle of the 19th century.

In the interwar period, in the 1920s and 1930s, Jaszczurowka flourished. The warm spring, two pools and the subsidiaries existed in Jaszczurowka till the 1960s. There were plans to modify the place and adjust it to balneological and therapeutic treatments. Unfortunately, after drilling a well which was to raise the

spring's output, due to the mixing with cold waters from the neighbouring stream, the warm spring disappeared. In the 1970s, a small geothermal bathing centre was given to exploitation in the centre of Zakopane. It uses warm (26 - 36°C) waters from two wells. In summer this place is flooded with tourists.

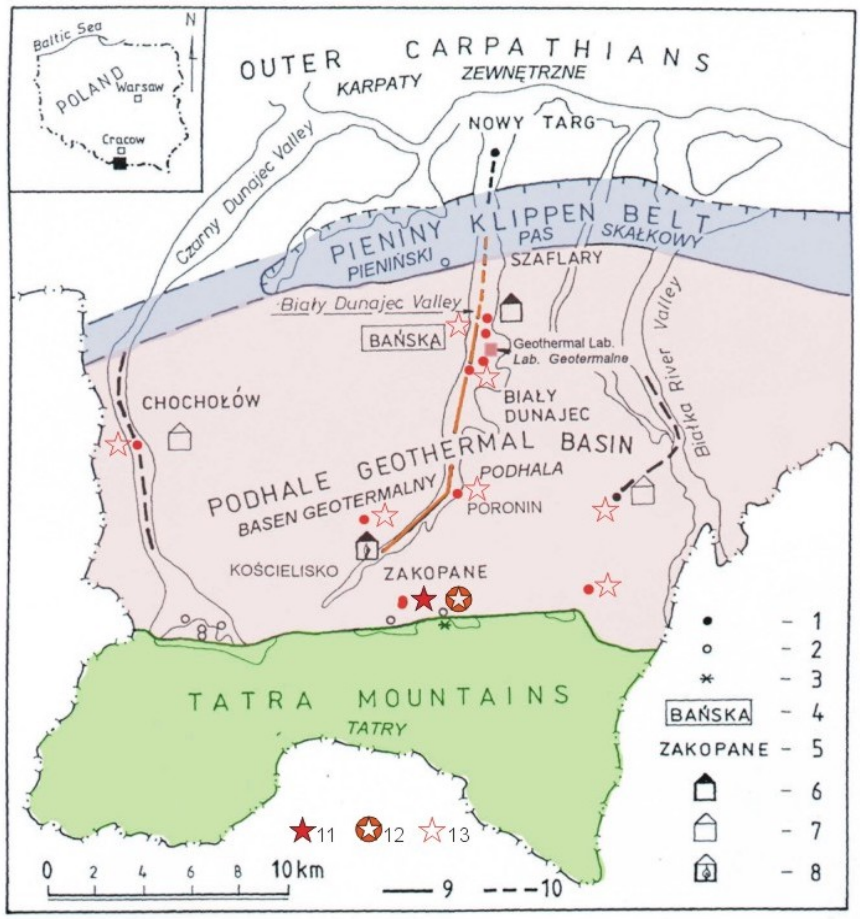

Fig. 2. The Podhale region, S-Poland: geothermal balneo-therapeutical and bathing centres and geothermal space-heating facilities

1. geothermal wells, 2. other wells, 3. geothermal spring in Jaszczurowka (existing untill 1960s), 4. locality with geothermal space heating system on-line (2001), 5. localities planned to be geothermally heated (2001 – 2001), 6. geothermal base load plant (commissioned in 1998), 7. geothermal heating plants planned, 8. central peak heating station (commissioned in 1998), 9. main transmission pipeline, 10. transmission pipelines planned, 11. geothermal bathing centre on-line, 12. geothermal bathing centre under construction (2001), 13. possible localities of geothermal balneo-therapeutical and bathing centres

There are exceptionally great possibilities to build water centres in this region. In fact, every locality where there are wells discharging geothermal waters up to 80 – 90°C can have its own geathermal centre tailored to the needs of both the inhabitants and tourists (Fig. 2). These can be not only large but also smaller centres fitted in local architecture and landscape. There are two finished projects, one of which has just started to be realized in Zakopane (population 30 000) – main city of the region. It will be one of the most modern geothermal water centres in

Poland, and will created on the site of the above mentioned swimming pool existing since the 1970s.

The project provides for the construction of a complex for rehabilitation and recreation offering a full range of treatments and services. There will be outdoor and indoor swimming pools there. The plans also include the building of a conference centre as a integral part of the complex. The facility will serve 1000 people per hour. The investment will be financed with Polish sources, with the municipal administration as one of the shareholders.

This is a long awaited project, indispensable to broaden the tourist offer of the city and to improve the quality of recreation in the main tourist centre in Poland.

Poddebice

The town is located in the Central Poland (Fig. 1). This area constitutes the relaxation and solace base for the inhabitants of Lodz – the second largest, after Warsaw, agglomeration in Poland. In Poddebice and the surrounding areas (just as nearby Uniejow which has geothermal prospects, too) are within the area of the occurrence of the Cretaceuos sedimentary formations – one of the most promising geothermal aquifers in the country. In this area, reservoir temperatures amount to 70 - 80°C, geothermal waters characterise with TDS up to 60 mg/l. (Sokolowski 1993, Ney 1995, Gorecki 1995). Waters have high curative and healing properties.

Poddebice is an example of a medium size town (population ca. 8.000) and county, which is dynamic and aims at the development of new spheres of balneotherapy, tourism and recreation in the area with no such traditions in the past. Thanks to a convenient location in the Central Poland and the qualities of geothermal waters, Poddebice has the chance of becoming a modern, regional centre of balneology and relaxation on the grounds of the warm waters.

The town and county have already developed feasibility studies and technical projects of complex geothermal energy use for heating, curing and recreation purposes. Now they are trying to gain suitable financial means and find investors. As far as balneology and recreation go, there are plans to establish a large local hydrotherapy centre. The project was highly rated by the renown Polish and foreign medical experts. The waters will be delivered from new wells which have to be drilled. At present (2001) the construction of a modern hospital is underway where about 800 treatments will be done every day. A sports and recreation centre will also take advantage of the waters. The biological rejuvenation centre will complement the medical functions of the balneo-therapeutical hospital.

The existence of the new geothermal centre will cause the development of the hotel base, services, agro-tourism and economy infrastucture, as well as - which is very crucial - it will influence unemployment by creating new jobs.

I n Uniejów - located about 10 km. from Poddebice - a geothermal heating network is being built, and in the future the construction of bathing and balneology centre will take place.

5. CLOSING REMARKS

Although not too numerous, geothermal spas offering curative and recreation services are an important element of health resorts in Poland. They have a long and interesting history. There is a growing need for this type of services, as well as an increased interest of the potential investors.

In the recent years, together with the projects of a comprehensive usage of geothermal energy in Poland, there occurred opportunities to develop new spas and water centres. They can be created near the biggest city agglomerations in the country, which are political, economical, and business centres. Such centres express great and constantly growing need for recreation, biological rejuvenation and treatment services. These facts are an important stimulus for the creation of new water centres, they should raise the interest among investors and also generate financial benefits.

Geothermal therapy and recreation is a promising line of business with great

opportunities of development in Poland, although not fully understood and exploited. One of the limitations of wide, adequate development is still insufficient promotion and funds.

Acknowledgements: The author is greatly indebted to Prof. J. Dowgiallo, Mr. A. Krawiec and Mrs. A. Lowczowska for supporting helpful information used in this paper.

REFERENCES

Dowgiallo, J. (1991). Geothermal systems of the Sudetes. Publs. Inst. Geophys. Pol. Acad. Sc., A-19 (236). Warszawa.

Dowgiallo, J. (1976). The Sudetes thermal waters. Acta Geol. Pol., Vol. 26, No. 4.. Warszawa, pp. 617 – 642 (in Polish, English summary).

Dowgiallo, J. (2000). Thermal water prospecting results at Jelenia Góra – Cieplice (Sudetes, Poland) versus geothermometric forecasts. Evironmental Geology 39 (5) March. Springer-Verlag.

Gorecki, W. [ed.]. (1995). Atlas of geothermal energy resources in the Polish Lowland. Krakow.

Gorecki, W. [ed]. (1998). Poland. [In] Atlas of geothermal resources in Europe.

Kepinska, B. (2000). The Podhale low-enthalpy system: geothermal characteristics. Proceedings of the World Geothermal Congress 2000. Japan.

Kepinska, B., Bujakowski, W., Ney, R. (2000). Geothermal energy country update report from Poland. Proceedings of the World Geothermal Congress 2000. Japan.

Krawiec, A. (1999). New results of the isotope and hydrochemical investigations of therapeutical waters of Ciechocinek Spa. Prz. Geol. Warszawa (in Polish, English summary).

Ney, R. (1995). Outline of geothermal conditions of Poland and regional geothermal basins. *Bull. Polish. Acad. Sc. Earth Sci.* Vol. 43, no. 4. Warszawa.

Sokolowski, J. (1993). Geothermal resources of Poland and possibility of their utilisation in environmental protection. *Exploration Technology, Geosynoptics and Geothermal Energy*. No 5-6. Krakow, pp. 67-80.

Sokolowski, J. [ed.]. (1995). Geothermal Provinces and Basins in Poland. Krakow, 124 pp.

Sokolowski, J. , Sokolowska J., Kepinska B. (1999). Using geothermal energy in Poland the passing millenniu. [in:] Cataldi, R., Hodgson, S., Lund, J. [eds]. (1999). Stories from a heated Earth. Our geothermal heritage. GRC, IGA. Sacramento, California.

Photos of some facilities in geothermal spas presented in the paper

Photo 1. Ladek Spa – main balneo-therapeutics station named *Wojciech*
(Source: Internet page www.ladek.pl)