INTERNATIONAL SUMMER SCHOOL on Direct Application of Geothermal Energy
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Chapter 1.8

WATER TOURIST CENTRES IN SLOVENIA – USERS OF GEOTHERMAL ENERGY

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Abstract

Slovenia is rich in thermal waters which are mainly used in natural health resorts for recreation and balneology, and very commonly, for heating and preparation of hot sanitary water. Slovenian spa tourism is important in economy of the country. For the next years, the most rapid increase is foreseen and for 2001 only it amounts to 6 %.

Slovenia already disposes with 28 natural springs and 48 locations where thermal water is captured in wells, having the total installed capacity of 139 MW_t. Of this amount, 103 MW_t or 74,1 % is under exploitation. In this manner, about 400 GWh_t/a of heat is produced. The present estimations indicate that Slovenia already disposes of 50.000 PJ of theoretical heat resources, of which about 12.000 PJ are exploitable and occur in geothermal aquifers only.

1. INTRODUCTION

Slovenia is young Central European country with Italy, Austria, Hungary and Croatia as bordering countries. It encompasses an area of 20.256 sq. km and has 1.966.000 of inhabitants. On the territory of Slovenia four main geographic units are encountered: Mediterranean in the southwest, Alps in the north, Dinarides in the south and Pannonian lowland in the east. The average annual temperatures range between 5,7 ºC and 13,5 ºC; the minimum and maximum temperatures are –31,0 ºC and +35,6 ºC respectively. These variations are mainly due to climatic changes and are most extreme in NE Slovenia where continental climate predominates. In the Alpine regions and along the Mediterranean coast the temperature differences are minor.

Geology (Figure 1) and tectonic setting of Slovenia are rather complex. The territory is a juncture area where three great tectonic units meet: Alps, Dinarides and the Pannonian basin. Their present situation is mainly related to Late Cretaceous subduction and collision of the African lithospheric plate beneath Europe, accompanied by extensive folding and thrusting. Deep-seated faults - grabens developed, enabling deep circulation of waters.

For heat convection towards the Earth's surface lithosphere thickness is of great importance. In Slovenia the thickness decreases from the West, where it amounts to approx. 50 km to the East where it is appreciably thinner being approx. 30 km only. The highest measured temperatures are known in the Mura basin and in the western parts of the Kr_ko basin. Besides the mentioned areas there are also other promising areas like Rogatec, the Celje basin and La_ko, Zagorje and Senovo synclines, the Ljubljana basin and the Mediterranean coast (Primorje). The Earth's thermal field on the territory of Slovenia is shown in the chart of temperature distribution at the depth of 1.000 m below the surface (Figure 2).

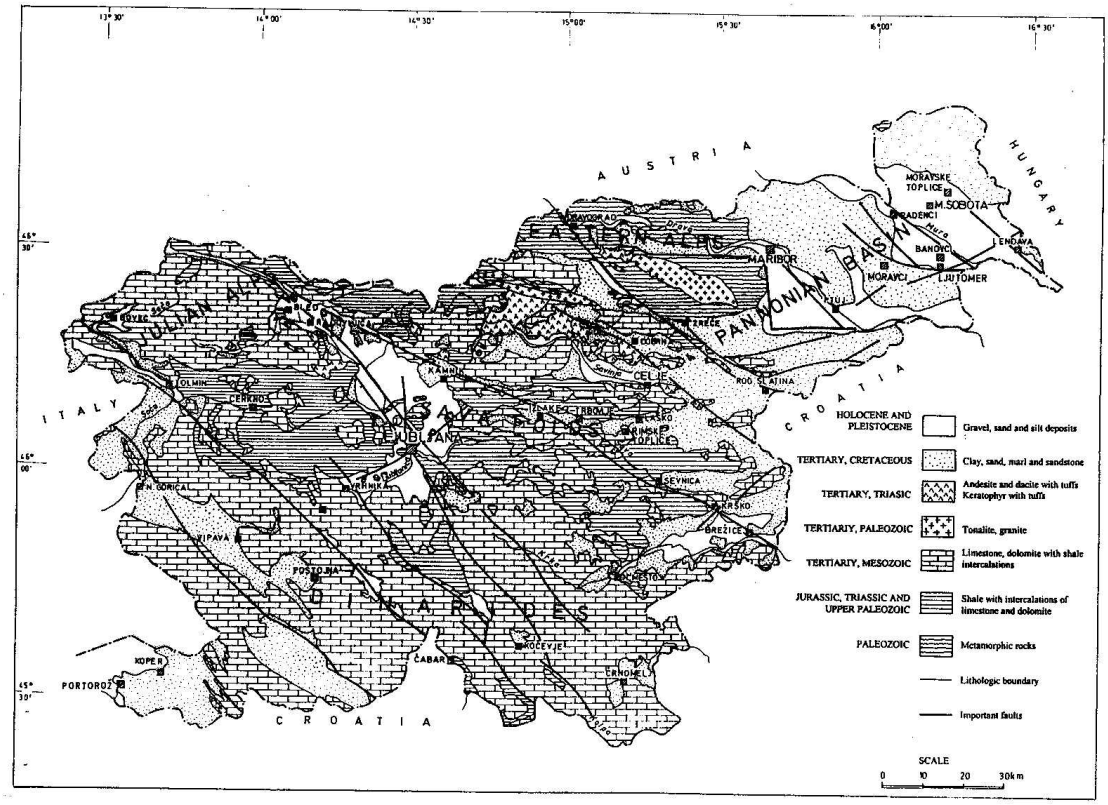

Fig. 1. General geologic map of Slovenia (after Buser, 1990).

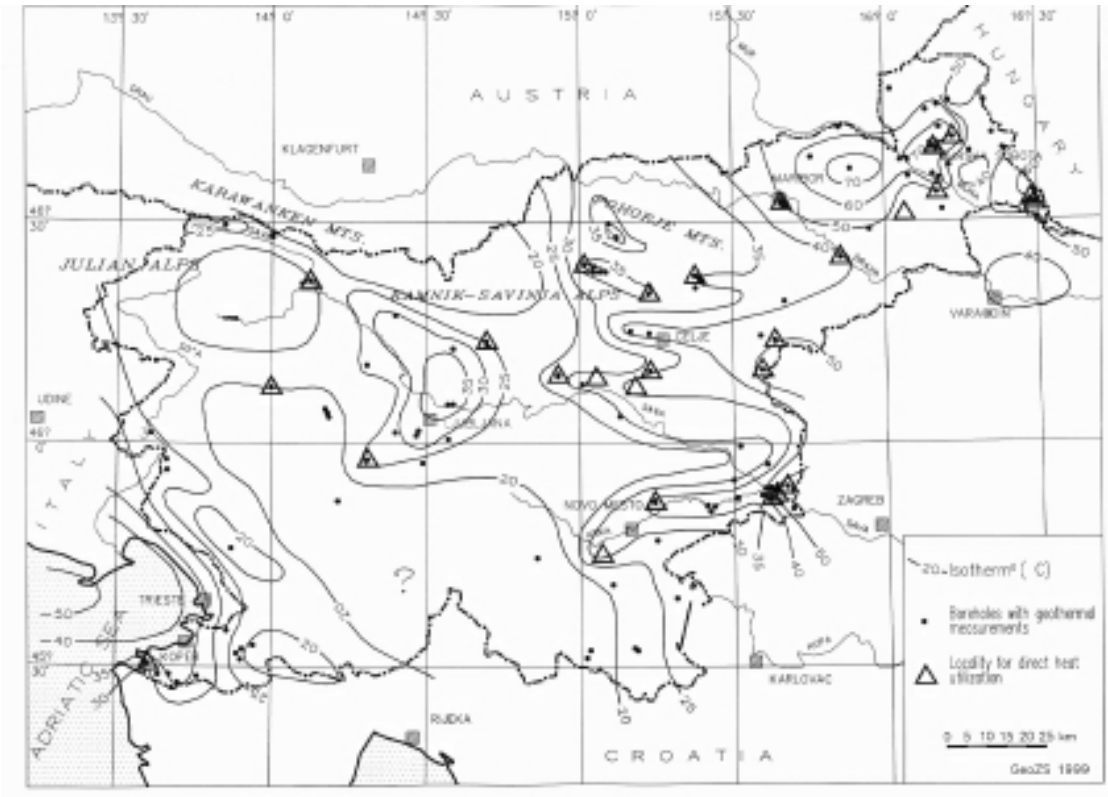

Fig. 2. Geothermal localities for direct heat utilization in Slovenia with isotherms at a depth of 1000 m (after Kralj & Rajver, 2000).

Slovenia is relatively rich in thermal water springs. 28 natural thermal springs are known with temperature close or above 20 °C, however, there are 58 localities where no surface thermal manifestations existed before drilling. All together having a total installed capacity of thermal power of 139 MW_t (Table 1 and 2).

Table 1: Natural thermal springs

No	Name of location	Altitude (m)	T_o (ºC)	T_w (ºC)	Yield (l/s)	Thermal power (kW_t)
1	Zatolmin	250	11	22	2-3	115
2	Bled (+ Staretov vodnjak)	482	10	19-22	5	205
3	Hotavlje (ob Kopacnici)	500	10	20-21	1-5	125
4	Zgornja Besnica	410	10	18	1-2	50
5	Vrhnika (Furlanove topl.)	295	10,5	21-22	5	230
6	Spodnje pirnize	309	10,5	18-23	3	125
7	Vaseno	435	10	22	1,5-2,5	100
8	Medija	320	10,5	21	6	325
9	Zagorje – Toplice	255	11	33	48	4010
10	Rimske Toplice	247	11	36-41	6	675
11	Topolcica	374	10	28-31	28-30	2300
12	Dobrna	367	10	35	8	835
13	Frankolovo	310	10,5	14-21	10-50	875
14	Zbelovo (Poljzane)	280	10,5	18,7	5	165
15	Toplicnik (Smarjeske T.)	166	11	16-18	230	5760
16	Klevez	175	11	22-25	6-15	520
17	Smarjeta	164	11	33,8	20	1900
18	Otocec na Krki	197	11	19	<1	
19	Dolenjske Toplice	180	11	36-38	12-13	1350
20	Malence pri Kostanjevici	152	11	17-20	<3	75
21	Toplicnik pri Kostanjevici	152	11	14-23	7	210
22	Kostanjevica	155	11	15-23	20	660
23	Buzeca vas	155	11	20-28	10-12	590
24	Perisce pri Catezu	150	11	32	2	140
25	Benedikt	243	11	20	0,5	20
26	Radenci	199	11	16,6	1,9	45
27	Podpec pri Ljubljani	290	10,5	12-15	0,5-3	20
28	Preserje pri Ljubljani	289	10,5	14-15	5-8	100
	Total:				483	21525

T_o ... mean surface annual temperature at the spring
T_w ... mean annual temperature of the spring

Table 2: Thermal boreholes

No	Name of location	Altitude (m)	T_o (ºC)	T_w (ºC)	Yield (l/s)	Thermal power (kW_t)
29	Zrece (B-1,2,3)	350-387	10	21-32	56	3822
30	Moravske Toplice (Mt-1,4,5,6,7)	190	11	60-70	40	10642
31	Lendava	160	11	46-72	13-52	4962
32	Banovci (Ve-1,2,3)	181	11	58-61	22,5	4600
33	Murska Sobota (SOB-1,2)	190	11	50	50	8190
34	Radenci (T-4/87)	210	11	41	1,2	125

35	Moravci v Slov. goricah (MO-1)	220	11	42	6	780
36	Ptuj (P-1,2)	220	11	29-34,5	18	1920
37	Maribor (MB-1,2,3,4,5,6)	257	11	43	9	1017
38	Rogaska Slatina	220	11	21-63	11,6	2047
39	Dobrna (V-7,8)	365	10	36	13	1088
40	Podlog pri Zalcu (P-1)	266	11	20	4,5	75
41	Lasko (V-5, R-1, K-2)	220	11	30-35,5	55	4211
42	Podcetrtek (V-1,3,4)	196	11	33-43	33	3740
43	Topolscica	375	10	29-32	40	3445
44	Lajze	389	10	48	27	4294
45	Rimske Toplice	220	11	38	50-60	6235
46	Medijske Toplice (V-1,2,3)	310	10	23,5-25	50	1936
47	Catez (K-1,2,3, V-3,15, L-1)	140	11	53-62,5	180	34074
48	Dobova (AFP-1)	138	11	62,5	15	2920
49	Kostanjevica (SI-1)	154	11	35,5	45	3673
50	Smarjeske Toplice (V-1-11)	170	11	32	40	2679
51	Dolenjske Toplice	180	11	30-38	25	2400
52	Vaseno (V-1-16)	450	10	22-30	21	816
53	Bled (T-8,9)	490	10	19-22	25-30	1210
54	Ljubljana (TB-3)	292	11	23	50	1465
55	Furlanove Toplice	292	11	21,5	20	460
56	Cerkno (Ce-2,3)	325	10	30-40	61	3864
57	Sempeter (Ce-1)	74	12	22	2	42
58	Portoro_ (LU-1, Pal-1)	1	13	23-24	41	1026
	Total:				483	117758

T_o ... mean surface annual temperature at the spring
T_w ... mean annual temperature of the spring

All recent users of geothermal energy, except Heat-pump users, use the temperature field between 25-90 ºC. The presently is known only one high-temperature aquifer in NE Slovenia – Termal II. By deep wells it was already proved, but currently, thermal waters of this temperature range are not used in Slovenia.

Exploitation of geothermal water on the territory of Slovenia has long tradition. Archeological findings indicate that the Romans and probably the populations before already used thermal water for bathing and heating of their dwellings. The first capturing of thermal water in Slovenia by deep drilling was performed in 1973 (Nosan, 1973).

The users are mainly Slovenian health and recreation resorts, that use thermal water for different purposes. The most common is the use for balneology, in outdoor and indoor swimming pools and as energy resource for heating of apartments and for sanitary water. In some health-resorts, i.e. Cateske Toplice (Catez Spa) near town of Krsko, the direct use of thermal water in intensive heating-season is not sufficient any more. In order to manage that, additional heat pumps are installed and other energy sources used during intensive heating-season.

Officially gathered data indicate that geothermal energy is estimated to currently supply approximately 703 TJ/yr of heat energy through direct heat applications in Slovenia.

According to recent estimates Slovenia disposes of 50.000 PJ of available theoretical resources of heat (of which 12.000 PJ are exploitable), in geothermal aquifers .

2. TOURISM AND ECONOMY

Tourism has multiplicative effects on the overall economy of the country. For one unit of tourist consumption in Slovenia, GDP increases for 2,69 times, national income for 1,88 times, the number of employed persons for 2,12 times and capital assets for 1,82 times. Various producers attain 4-10 times

higher prices as in the case of export to the foreign market.

As a rule, tourism is developing in more pristine and ecologically clean environments. new working places enable demographic stability. As tourism is incompatible with "dirty" and "noisy" idustry, it influences appreciably the preservation of unpolluted environment. But it must be emphasised that tourism may also have a negative influence on the environment, i.e. large hotel complexes incompatible with the culture and tradition of the nation, different architectonic styles and concentrated touristic capacities in one place.

3. SLOVENIAN NATURAL HEALTH RESORTS

3.1. General aspects

Slovenian Association of Natural Health Resorts (Fig. 3) joins 17 members with the annual income of about 200 million Deutsch Mark. From this amount, about 60-100 million is reinvested. Slovenian natural health Resorts dispose of about 33.000 m^2 of the swimming pool areas, 6700 hotel beds, 1400 beds in apartments and 3400 places in autocamps. The number of guests and overnight stays for different seasonal periods from the year 1990 to 2000 are given in the Table 3.

Fig. 3: Locations of Slovenian Spas

Table 3: The number of guests and overnights in Slovenian natural health resorts

Year	No. of tourists	No. of overnights
1990	287.155	1.863.783
1991	255.580	1.552.759
1992	305.675	1.776.808
1993	327.248	1.895.234
1994	349.594	2.014.426
1995	361.562	1.990.935
1996	358.961	1.951.339
1997	377.119	2.089.718
1998	380.950	2.084.616
1999	374.987	1.978.864
2000	431.971	2.235.204

The shear of foregn guests is 37 %. The shear of overnights which is paid by health insurance companies is relatively low (12,5 %) in comparison with Germany where it amounts to 35 %.

Slovenia also disposes with several smaller objects with natural thermal water, which are commonly located at natural springs and they are not included in any studies. The capturings are primitive and serve for local people only. The captured water is natural and is not treated with chemicals.

3.2 Energy use

Practically all Slovenian natural health resorts use thermal water for energy purposes, particularly for heating and preparation of sanitary water. the data on thermal water utilisation in 1999 are gathered in Table 4..

TABLE 4. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 1999

[1)] H = Space heating

B = Bathing and swimming (including balneology)

Locality	Type[1)]	Maximum Utilization			Capacity	Annual Utilization		
		Flow Rate	Temperature (^oC)			Ave. Flow	Energy	Capacity
		(kg/s)	Inlet	Outlet	(MW_t)	(kg/s)	(TJ/yr)	Factor
Moravci	H,B	52.1	65.1	37.1	6.10	32	113.9	0.59
Murska Sobota	H,B	25	50	33	1.78	11	24.7	0.44
Terme Lendava	H,B	9	53	28	0.94	6.5	21.4	0.72
Ptuj	B	5.5	39	29	0.23	5.5	7.3	1
Moravci-Buckovci	B	7	43	28	0.44	0.23	0.5	0.04
Banovci	H,B	4.2	68	25	0.76	2.8	15.9	0.66
Zrece	H,B	22	29.9	24	0.54	15	11.7	0.68
Podcetrtek	H,B	50	35.4	30	1.09	28	20.1	0.58
Rogaska Slatina	B	6	55.2	30	0.63	2.5	8.2	0.41
Snovik	B	15	30.4	28	0.15	5	1.6	0.33
Dobrna	B	8.1	36	32	0.14	6.5	3.4	0.8
Topolsica	B	30	32	20	1.51	22	34.8	0.73
Medija	H,B	35	24	21.1	0.42	14	5.8	0.44
Smarjeske Topl.	H,B	40	32	17	2.51	30	59.4	0.75
Lasko	B	40	34	33	0.17	20	2.6	0.5
Rimske Toplice	H,B	7.3	38	32	0.18	5.2	4.1	0.71
Dolenjske Topl.	B	19.6	34.2	32	0.18	9	2.4	0.43
Terme Catez	H,B	80	60	30	10.04	40	158.3	0.5
Bled	B	10	21.7	20	0.07	10	2.2	1
Cerkno	H,B	40	30	28	0.34	10	2.6	0.25
Dobova	H,B	15	63	38	1.57	7	23.1	0.47
Portoroz	B	0.8	23	16	0.02	0.6	0.5	0.67
Maribor	H,B	10	40	21	0.80	1.5	3.8	0.15
TOTAL		531,6			30,6	279,83	528,3	0.55

3.3 Balneology

Slovenian health resorts prefere preventive treatments and education regarding health preservation, when rehabilitation is not required yet.

In many independent controlling studies, thermal waters are a proven therapeutic medium, similar to medicaments. Experiences indicate that stationary rehabilitation is essentially more effective than ambulance stations in the patient's living environment. thermal waters are used mostly for medicinal bathing and recreation swimming pools. They have healing effects for cardiovascular and orthopedic-rheumatologic diseases. Indications for Slovenian natural health resorts are gathered in Table 5.
With respect to the temperature of thermal waters, they can be subdivided into

- hypothermal (20-34° C)
- homeo- or isothermal (34-38° C), and
- hypothermal (< 38 ° C).

Table 5: Indications for Slovenian natural health resorts

Spa	A	B	C	D	E	F	G	H	I	J	K	L	M
Catez	?	?	?			?		?				?	
Dobrna	?	?	?			?	?	?		?			
Dolenjske T.		?	?			?		?				?	
Lasko		?	?					?					
Lendava		?	?			?		?					
Moravske T.		?	?						?		?		
Atomske T.		?	?					?	?	?			
Portoroz		?	?		?	?		?	?	?	?		
Ptuj		?	?		?			?		?			
Radenci	?	?	?		?		?					?	
Rogaska	?	?	?	?	?		?		?			?	?
Smarjeske T.	?	?	?					?		?			
Topolcica	?	?	?					?		?	?		
Zrece		?	?			?		?		?	?		?

A – heart and circulatory diseases
B – revmatic diseases
C – injuries to the locomotor system
D – diseases of the digestive system
E – metabolic diseases
F – gynecological diseases
G – kidney and urinary tract diseases
H – neurological diseases
I – skin diseases
J – neurotic disorders
K – respiratory ailments
L – mounth and teeth diseases
M – eye diseases

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