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Austria – Country Update

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ABSTRACT

Only 7 deep boreholes have been drilled in Austria between 2005 and 2009 (cumulative depth 9,468 m). They all were drilled for balneological purposes, mainly wellness. No geothermal project has been launched in Austria since 2005. The main reason is the lacking public support and the low feed-in tariffs for electric power (7.3 ct/kWh in Austria compared to 23 ct/kWh in Germany for combined geothermal heat and power production).

In the next future new deep geothermal projects can be expected in the Vienna Basin.

The number of ground source heat pumps showed a steady increase since 2005. The total number of units is estimated as high as 50,000 having a capacity of 600 MW_{th} and 800 GWh/yr.

1. INTRODUCTION

Deep geothermal exploration in Austria (area 83,871 km², 8.13 million inhabitants in 2001) mainly takes place in the Molasse Basin of Upper Austria and the Alpine–Carpathian intramontane basins (Styrian Basin; to a minor extent in the Vienna Basin) and the Pannonian/Danube Basin (Fig. 1).

The Vienna Basin which is situated in the transition zone between the Alps and the Carpathians is regarded as one of the future main target areas for direct use and power generation as temperatures of more than 200 °C can be expected.

Table 1 gives an overview of the geothermal wells drilled in Austria between 1977 and 2009 and the wells drilled in the reporting period 2005 to 2009. More than 50 % of the new wells were drilled in Austroalpine units. They all were intended for balneological use.

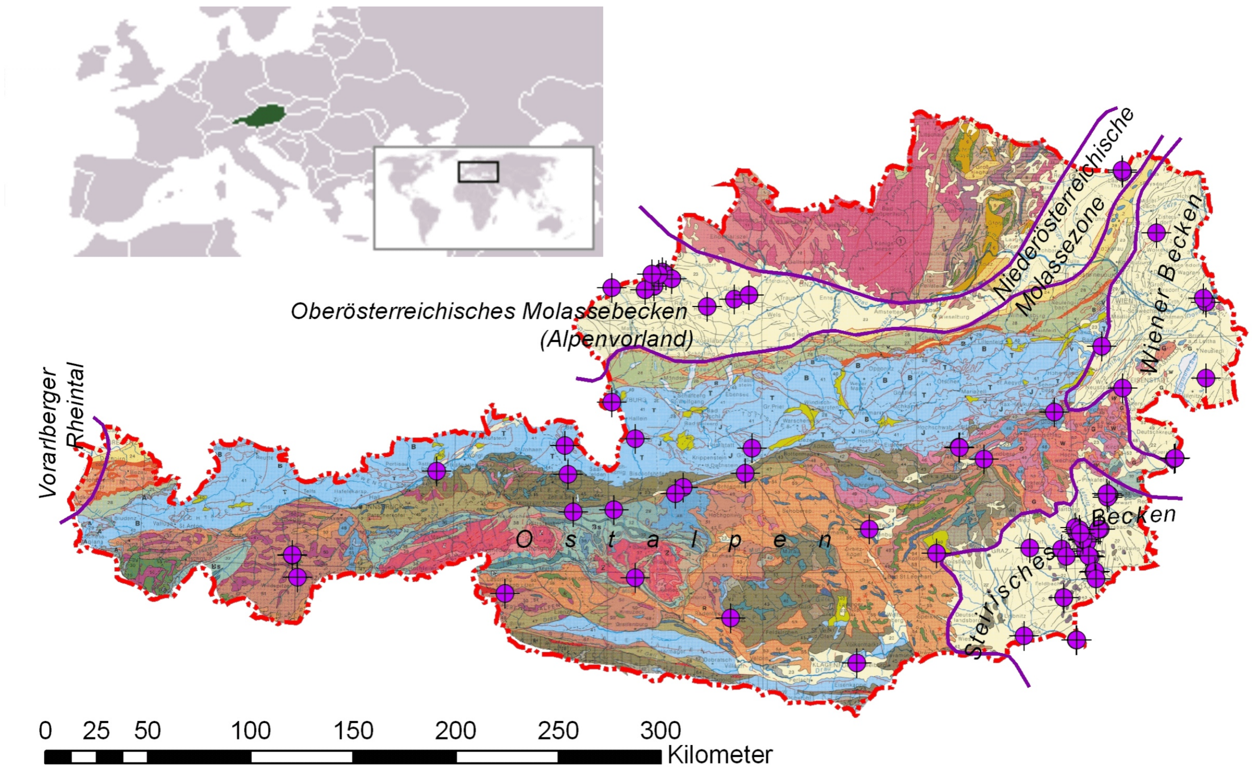

Figure 1: Geothermal exploration wells in Austria (1977-2009).

Table 1: Geothermal drillings in Austria (period 1977 – 2009).

Unit	Total number of wells	No. of new wells 2005-2009	Cumulative depth (m)
Styrian Basin	27	1	41,723
Upper Austrian Molasse Basin	12	0	25,056
Vienna Basin and Lower Austrian Molasse Basin	6	1	6,482
Northern Calcareous Alps and Upper Austroalpine units (mainly carbonate rocks)	9	0	14,190
Lower, Middle and Upper Austroalpine Units (mainly crystalline rocks)	15	4	24,867
Pannonian Basin	1	1	860
Total	70	7	113,178

2. DEEP GEOTHERMAL

2.1 Vienna Basin

The structure of the 200 km long and 50 km wide Vienna Basin is a result of tectonic movements since the lower Miocene. The Miocene basin filling with a maximum thickness of more than 5,500 m is underlain by allochthonous and subthrust floors. The gross part of the Basin lies in Austria, the rest in Czech Republic and in Slovakia. The geological knowledge is based on more than 3,500 hydrocarbon drillings (HAMILTON, WAGNER & WESSELY, 1999) and extended seismic surveys, including 3-D-seismic.

The main features of the Basin in the Austrian part are the marginal blocks along the western border. These blocks are bound to the east and south east by faults with displacements of up to 6,000 m and 4,000 m respectively (Steinberg fault system and Leopoldsdorf fault system). On the down-thrown blocks of these faults deep depression zones are developed (Fig. 2).

The Miocene Basin filling comprises sediments of Eggenburgian to Pannonian age. Permeable horizons, represented by sand and sandstones, conglomerates and carbonate rocks contain important oil and gas fields. Some coarse clastic sequences like the Aderklaa Conglomerates form a regionally denotative aquifer. Their applicability for geothermal purposes is questionable in the next future due to possible conflicts with interests of the hydrocarbon industry.

The main targets for the geothermal exploration lie in the pre-Neogene basin floor where thick carbonate rock units of the Northern Calcerous Alps offer excellent prerequisites for the production of high flow volumes. The Leopoldsdorf fault ("Leopolsdorfer Bruch in Fig. 2) separates the carbonate units on the up-thrown block in the west from the down-thrown block in the east. WESSELY, 1983 proofed the existence of a dynamic flow system in the up-thrown block receiving its recharge in elevated mountainous limestone and dolomite rocks in the west and northwest boundary of the basin shown by a pronounced negative temperature anomaly in a well near the recharge zone down to a depth of 6,000 m (drilling Berndorf 1; thermal gradient 1.13 °C/100 m, Fig. 3.). The aquifer is bounded to the east by the Leopoldsdorf fault and to the south by less permeable rocks of the Greywacke zone. Upward movement of deep groundwater cause a positive thermal anomaly on the Oberlaa-Laxenburg high in carbonate rocks of the basin floor and in transgressive neogene coarse clastic horizons. The discharge mechanisms of the dynamic flow system are not well understood at the moment.

At the down-throw block the permeable carbonate rocks (mainly Hauptdolomit and Wettersteindolomit of the Göller nappe) are lowered to 3,000 to 6,000 m, their bottom can be expected in a depth range of more than 8,000 m (WESSELY, 2006). The aquifer contains NaCl-water with a TDS of 150 g/l; temperatures can be expected in the range between 100 °C and 215 °C (WESSELY, ibid).

For the urban development area "Airfield Aspern" in the eastern part of Vienna a deep geothermal project for heating and cooling is carried out. Stage one (2008 – 2010) of the urban development plan envisages 1,500 accommodation units with 210,000 m² of living-space and 43,000 m² office and business area. The expected thermal power for heating and cooling is expected as high as 18 MW for stage one and 39 MW for the second stage to be terminated until the year 2020 covering a land surface of 240 ha.

The drillings of the geothermal doublet will reach a total depth of some 4,800 m (production well) and 3,900 m (reinjection well). The aquifer is in upper Triassic Hauptdolomit beds of the Göller nappe. Production temperatures are expected as high as 140 °C, flow volume in the order of 100 l/s (360 m³/h).

In 2005 a well intended for balneological use was drilled at the south eastern part of the Vienna basin near the village of Engelhartstetten. It targeted Middle Triassic carbonate rocks which crop out southeast of the Danube (Fig. 4). Thermal waters found at shallow depth at Bad Deutsch Altenburg show the existence of a pronounced discharge area of deep groundwaters (note the 25 °C isotherm at shallow depth in Fig. 5).

The distance of the well Engelhartstetten 1 to the outcrop of the Triassic carbonate rocks at Bad Deutsch Altenburg is only 2 km. It met a neogene sequence of 632 m thickness consisting of sediments of Badenian and Karpatian age. The Aderklaa Conglomerates had a thickness of 153 m. A fractured zone between 598 and 599 m in the conglomerates was successfully tested. The preneogene basement is formed by Upper Lias to Middle Dogger euxinic shales. These shales were drilled to the end depth of the borehole at 1,122 m. Triassic carbonates were not reached by the bore.

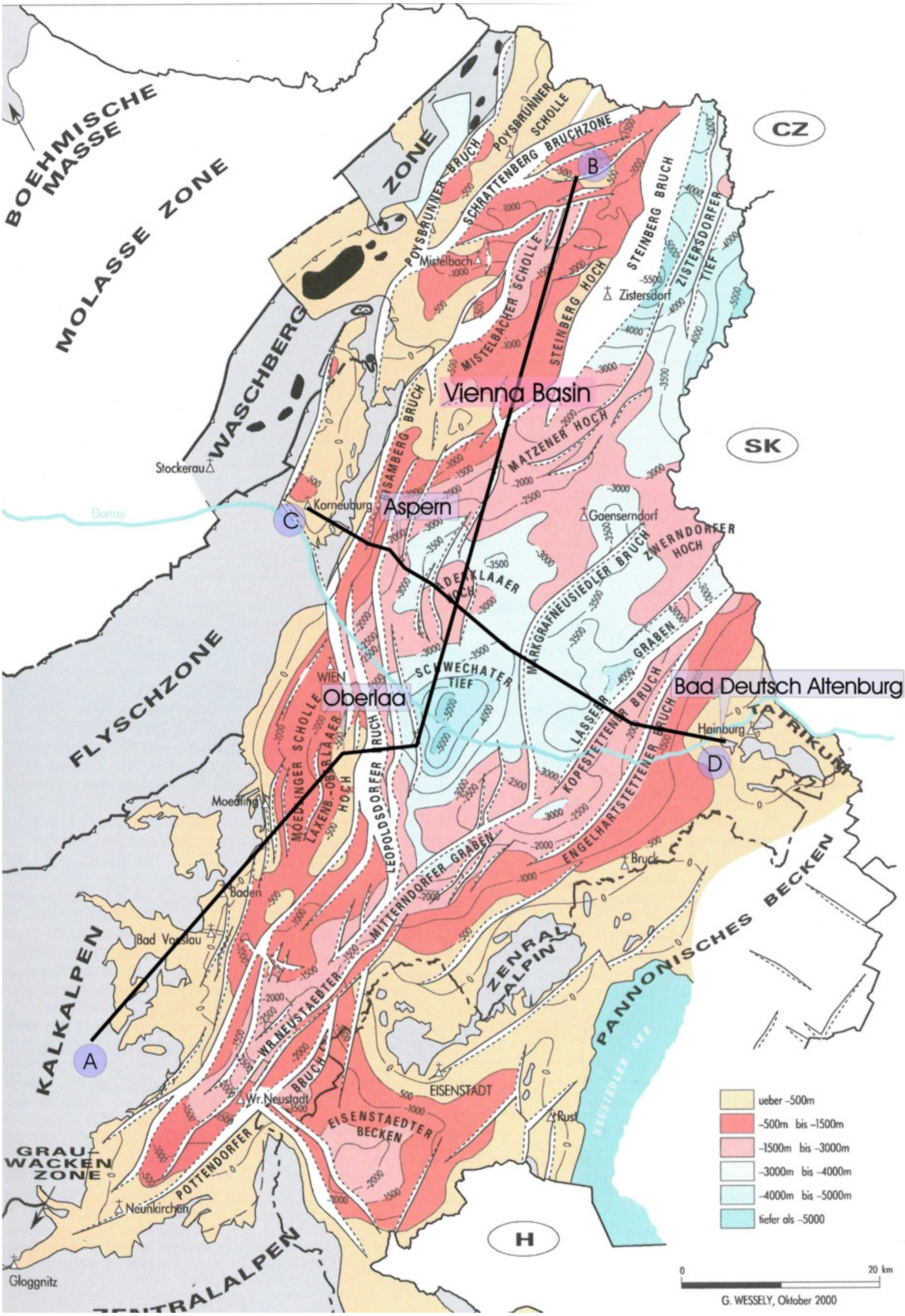

Figure 2: Structural map of Vienna Basin (WESSELY, 2006) and position of profiles.

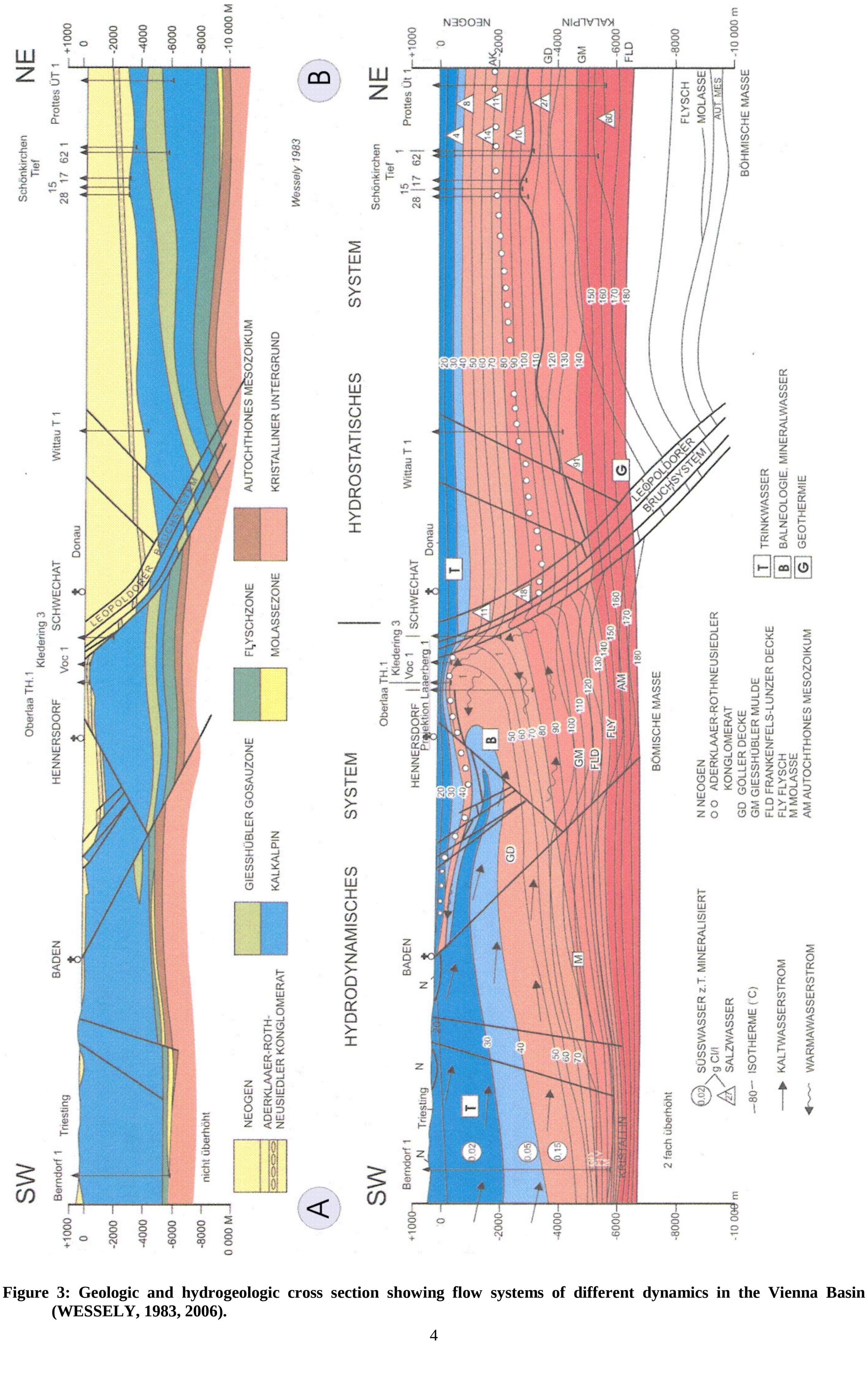

Figure 3: Geologic and hydrogeologic cross section showing flow systems of different dynamics in the Vienna Basin (WESSELY, 1983, 2006).

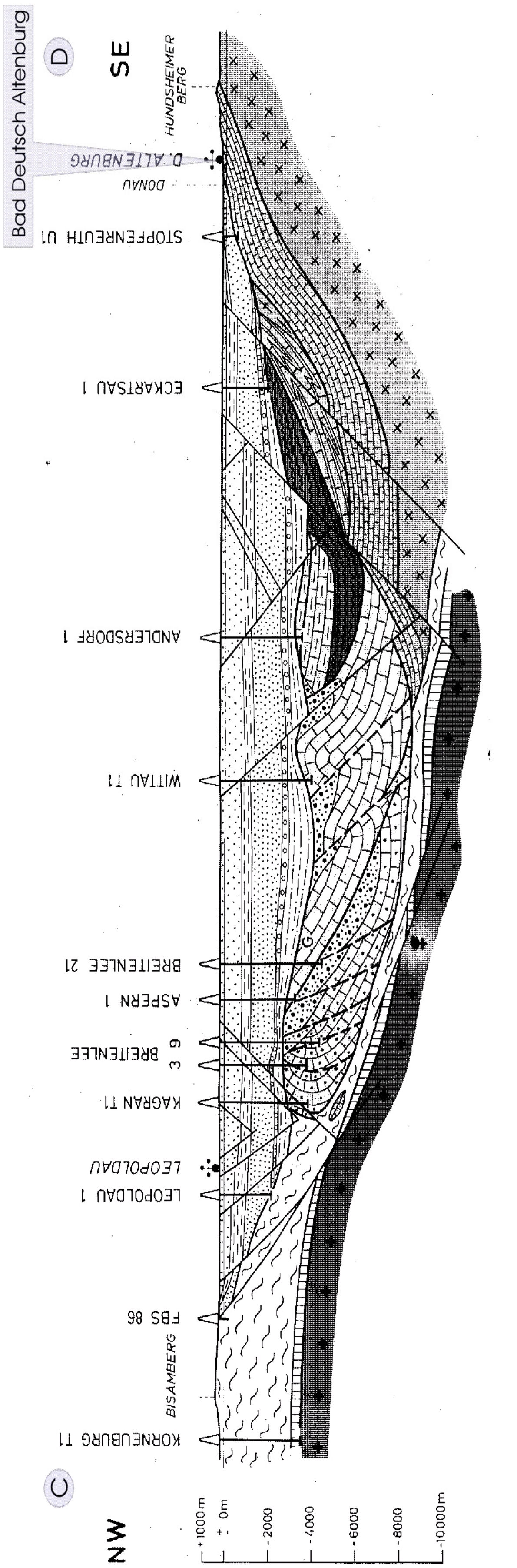

Figure 4: Geologic traverse section (NW – SE) through the Vienna Basin (WESSELY, 1983)

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The temperature profile of the borehole proofed that it is situated outside the thermal anomaly. Temperature at 600 m is only as high as 33 °C. The water is of the sodium-chloride-bicarbonate type with a TDS of 5.6 g/l and shows similarities to the waters at Bad Deutsch Altenburg. The H_2S and HS content of 198 mg/l is the highest value of all European mineral and thermal waters. The water is intended for balneological use.

2.2 Upper Austrian Molasse Basin

The Upper Austrian Molasse Basin is so far the most developed geothermal area in Austria. The main aquifer is in Upper Jurassic (Malmian) dolomites and limestones. The water tapped in the aquifer are low mineralized sodium bicarbonate chloride waters. Temperatures up to 110 °C can be achieved. Currently 6 geothermal district heating systems (Fig. 6) are in operation.

For the period 2001 to 2005 data on the geothermal use are available (GOLDBRUNNER et al, 2007; see Tab. 2).

Table 2: Geothermal heat supply of Upper Austrian geothermal projects (period 2001 – 2005)

Geothermal Heat supply [MWh]		2001	2002	2003	2004	2005
Altheim						
	District heating	-	-	26,444	26,587	27,369
	ORC					916
Geinberg						
	Total	30,349	30,275	29,662	29,736	31,542
	100/70 °C	10,404	10,397	9,990	9,179	8,705
	70/40° C	15,969	15,681	14,648	15,869	18,759
	< 40°C (green house)	3,976	4,197	5,024	4,688	4,078
Obernberg						
	Total	-	6,257	6,473	-	7,584
Haag						
	Total	4,300	4,554	4,844	4,947	5,434
Simbach-Braunau						
	Total	-	-	56,363	57,212	58,263
	geothermal	-	-	39,185	40,694	39,221
	fraction of geoth. [%]	-	-	70	71	67
St. Martin						
	Total	-	18,890	21,452	24,074	25,966
	geothermal	4.560	8,830	11,568	12,420	14,774
	fraction of geoth. [%]	-	47	54	52	57

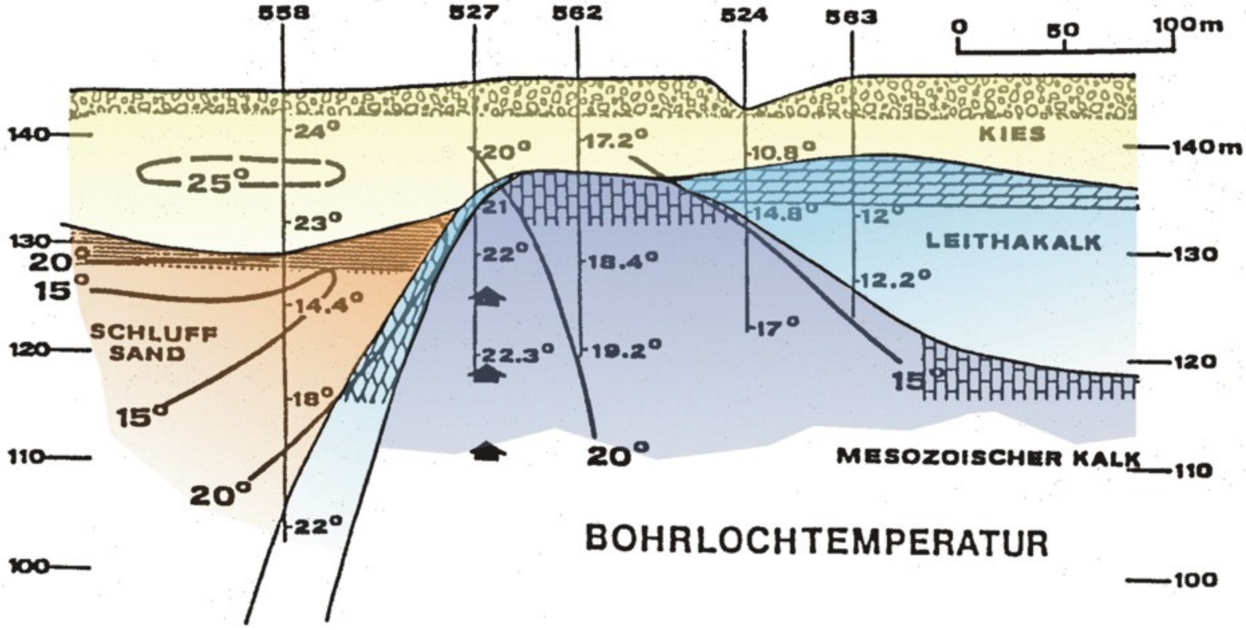

Figure 5: Cross section along the river Danube at Bad Deutsch Altenburg showing the existence of a pronounced thermal anomaly (after GANGL, 1988).

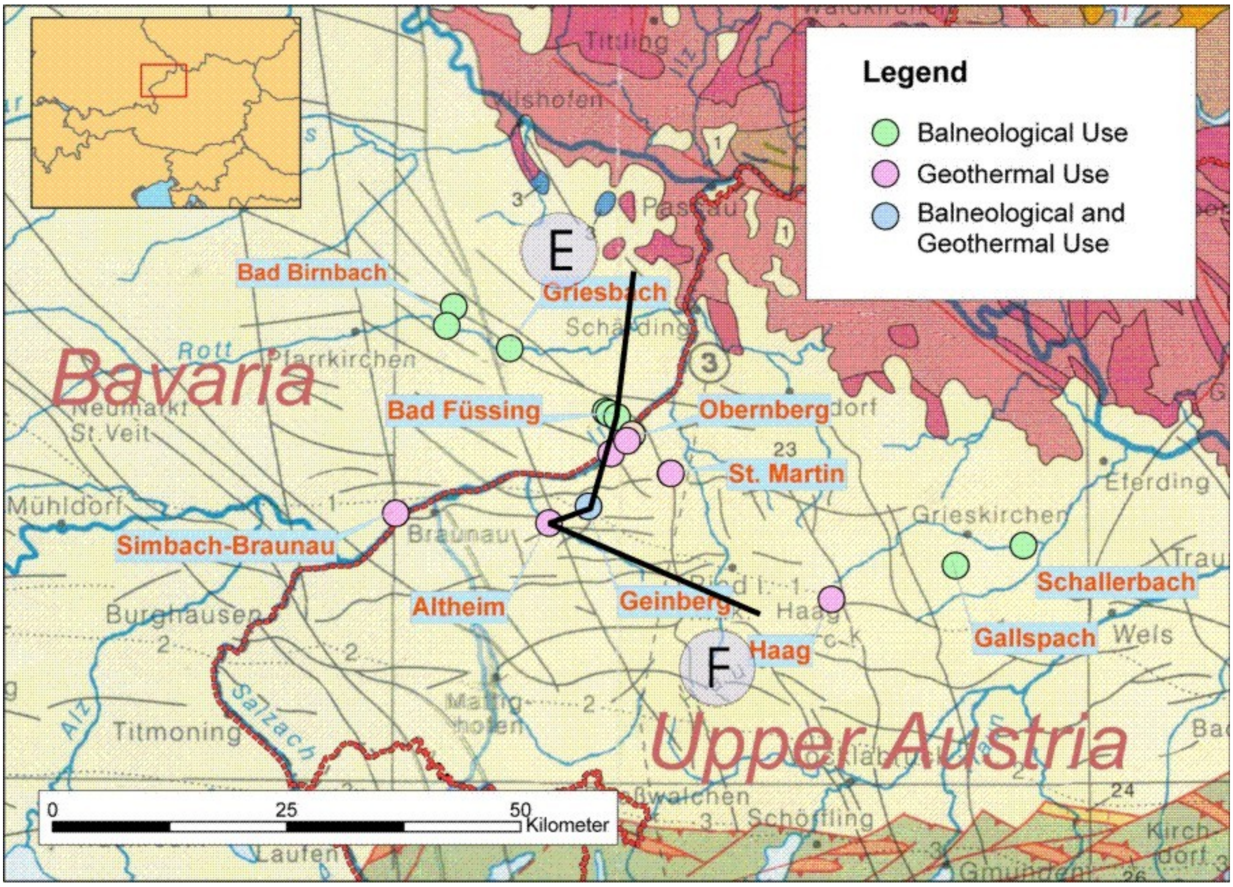

Figure 6: Geothermal wells and wells for balneological use in the Upper Austrian/Bavarian border region and position of profile

In the period 2005 to 2009 no geothermal drilling activity took place in the Upper Austrian Molasse Basin. In contrast the German part of the Molasse Basin, especially in the area around Munich, encountered enhanced drilling activity stimulated by high feed in tariffs for geothermal produced electrical power in combination with district heating.

A geothermal district heating project in the Upper Austrian Molasse basin is planned for the town Ried im Innkreis, some 30 km east of Geinberg.

The production well is situated at the down-thrown block of the Ried fault which has a displacement of some 800 m and will reach the Malm aquifer at a depth of 2,500 m. The reinjection well will be drilled at the up-thrown block of the fault and will tap the carbonate rocks at a depth of 1,670 m. Production temperatures are expected as high as 105 °C, geothermal power is expected as high as 15 MW.

The Simbach-Braunau geothermal project saw a constant growth of the district heating net with a total installed thermal capacity of nearly 40 MW. In 2009 a ORC unit went in operation with a produced electric power of 220 kW. The project is supported by the EU (project LOW-BIN).

2.3 Styrian Basin

The Styrian Basin (Fig. 8.) saw only limited drilling activity in the period 2005 – 2009 as only one borehole (Tatzmannsdorf Thermal 3) was sunk. Tab. 3 gives some information on the geothermal projects in the Styrian Basin currently under operation.

Table 3: Geothermal projects in the Styrian Basin.

Project	Use	Flow Rate l/s	T_{in} °C	T_{out} °C	Capacity MW
Sebersdorf/ Waltersdorf	B	2,5	33	30	0.03
Bad Waltersdorf	D, B, G	17	63	30	2.3
Bad Blumau	E, D, B	30	110	50	7.5
Fuerstenfeld	D	5	85	50	0.7
Loipersdorf	B	4	61	30	0.5
Bad Radkersburg	B	5	70	30	0.8

B = balneology, D = district heating, G = greenhouse, E = power production.

The geothermal district heating project at Fuerstenfeld is running at low capacity due to problems with the reinjectivity of the sandstone aquifer.

The only drilling to be performed in the period 2005 – 2009 was Bad Tatzmannsdorf 3 which was intended for balneological use in the thermal spa and health resort of Bad Tatzmannsdorf. The drilling was located at the down-thrown block of a fault with a displacement of more than 200 m. The main target was in the preneogene basement (Fig. 9.).

The drilling met the basement consisting of green shists, quartz shists and sericite slate at a depth of 812.5 m and stayed in it to its end depth of 1,024 m. It encountered several fracture zones as indicated by borehole measurements. The transmissivity of the hole section was however only in the order of 6 * 10^{-7} m²/s. The water type was sodium-sulfate-chloride-bicarbonate with a TDS of 2.8 g/l. Production temperature was as high as 43 °C.

For thermal water production a sand-gravel horizon in the Baden formation (Bulimina-Bolivina-Zone) between 425.6 and 455.6 m was successfully perforated. After completion of the well using casing inside filter and gravel pack long term outflow test resulted in a free overflow rate of 4.5 l/s at a temperature of 33 °C. The thermal water is of the sodium-calcium-magnesium-bicarbonate type with a TDS of 4.5 g/l, free CO_2 is in the order of 1.2 g/l.

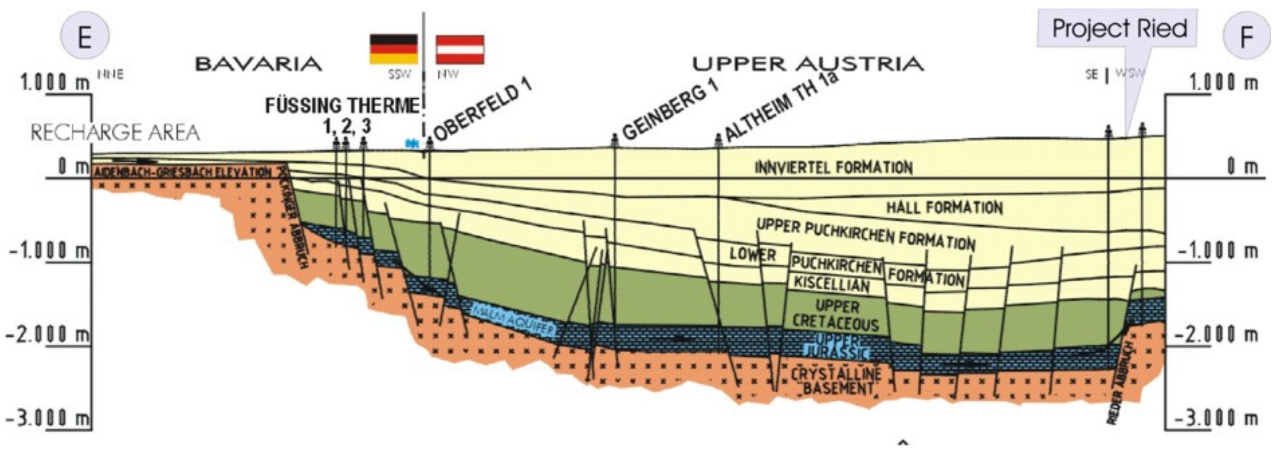

Figure 7: Cross section showing the position of the planned geothermal project Ried (profile after GOLDBRUNNER, 2000).

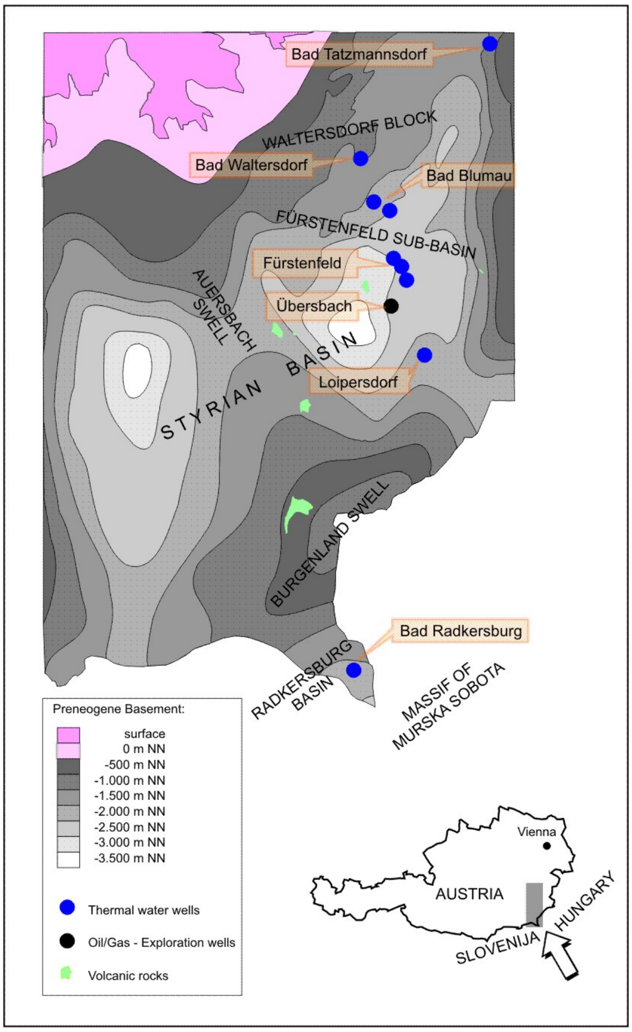

Figure 8: Map of the Eastern part of the Styrian Basin.

2.3 Alpine region

The gross of boreholes in the period 2005 – 2009 was drilled in Alpine regions. All were intended for balneological purposes, mainly wellness. Table 4 gives some data of the boreholes.

Table 4: Geothermal wells drilled in the Alpine region of Austria (period 2005 – 2009).

Well name	Year	Country	Total depth [m]	Result
St. Jakob Th 1	04/05	Tyrol	1,882	NS
St. Kanzian Th 1	05	Carinthia	1,700	S
Kaprun Th 1	06	Salzburg	560	S
Altenmarkt Th 1	06	Salzburg	2,310	NS

country = federal country, Result: S = successful, NS = non successful,

The St. Kanzian Thermal 1 well was located at the crystalline border of the Klagenfurt basin which is an intramontane basin reaching a maximum depth of several thousand meters (Fig. 10).

The bore encountered 350 m neogene sediments consisting of conglomerates, lacustrine clays and tuffites. The crystalline rocks drilled to the end depth of the borehole consist of mica shist, quarzitic shists and marble, which appeared near the end depth of the borehole. Fractured zones lie mainly in an interbedding sequence of mica shist, quarzitic shists and marble between 1,445 and 1,550 m. Pumping tests resulted in a maximum flow rate of 2.3 l/s. Gas-water ratio is as high as 13 : 1. The gas contained 16 vol% methane and 50 % vol CO_2. The methane originates from coal beds in the neogene sediments and migrates into the crystalline rocks. The water is of the sodium-chloride-bicarbonate type with a TDS of 23.7 g/l. Deuterium and oxygen-18 show a clear deviation from the global meteoric water line.

3. SHALLOW GEOTHERMAL

The number of ground source heat pumps shows a steady increase since 2005. The total number of units is estimated as high as 50,000 having a capacity of 600 MWth and 800 GWh/yr. The exact number of the GSHP is hard to assess, as only groundwater wells are registered in the files of the water right authorities

4. CONCLUSIONS

Austria has seen only limited activity on deep geothermal in the reporting period 2005 – 2009. The obstacles and barriers stated in GOLDBRUNNER, 2005 are still active thus hindering enhanced use of deep geothermal energy in Austria. New projects can be expected in the Vienna basin especially at the border of the capital Vienna. The Upper Austrian Molasse Basin will see a moderate growth of the number of projects and some enlargement of existing projects by additional drillings.

GSHP have reached a wide spread in Austria and a steady growth can be expected in the future as more than 50 % of the new built one family houses are supplied by heat pumps. Poor quality of drilling and completion of down hole heat exchangers have led to conflicts with ground water supplies so quality assurance will be an important issue in the future.

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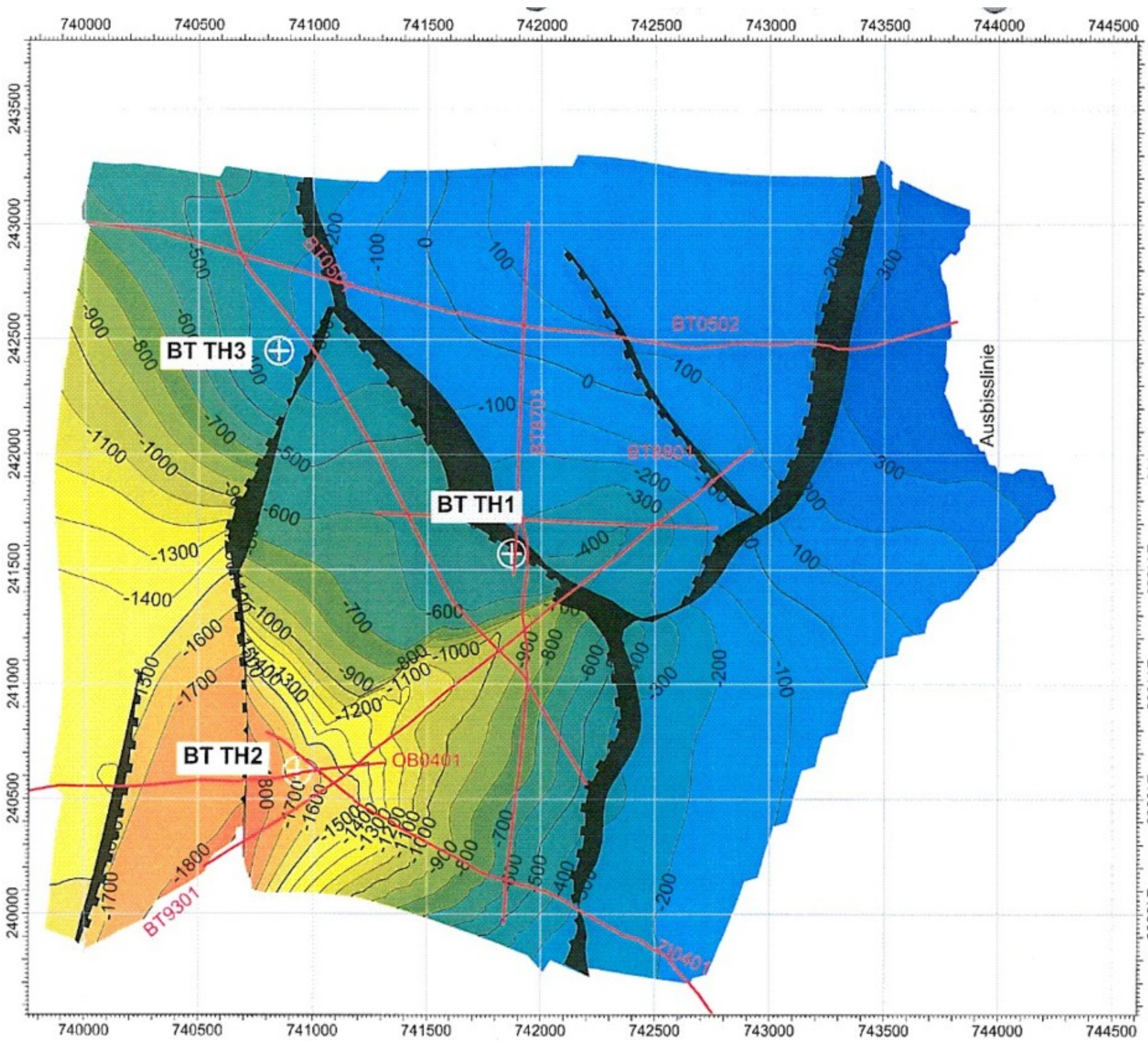

Figure 9: Structural map of preneogene basement showing the position of well Tatzmannsdorf Thermal 3 (BT TH3).

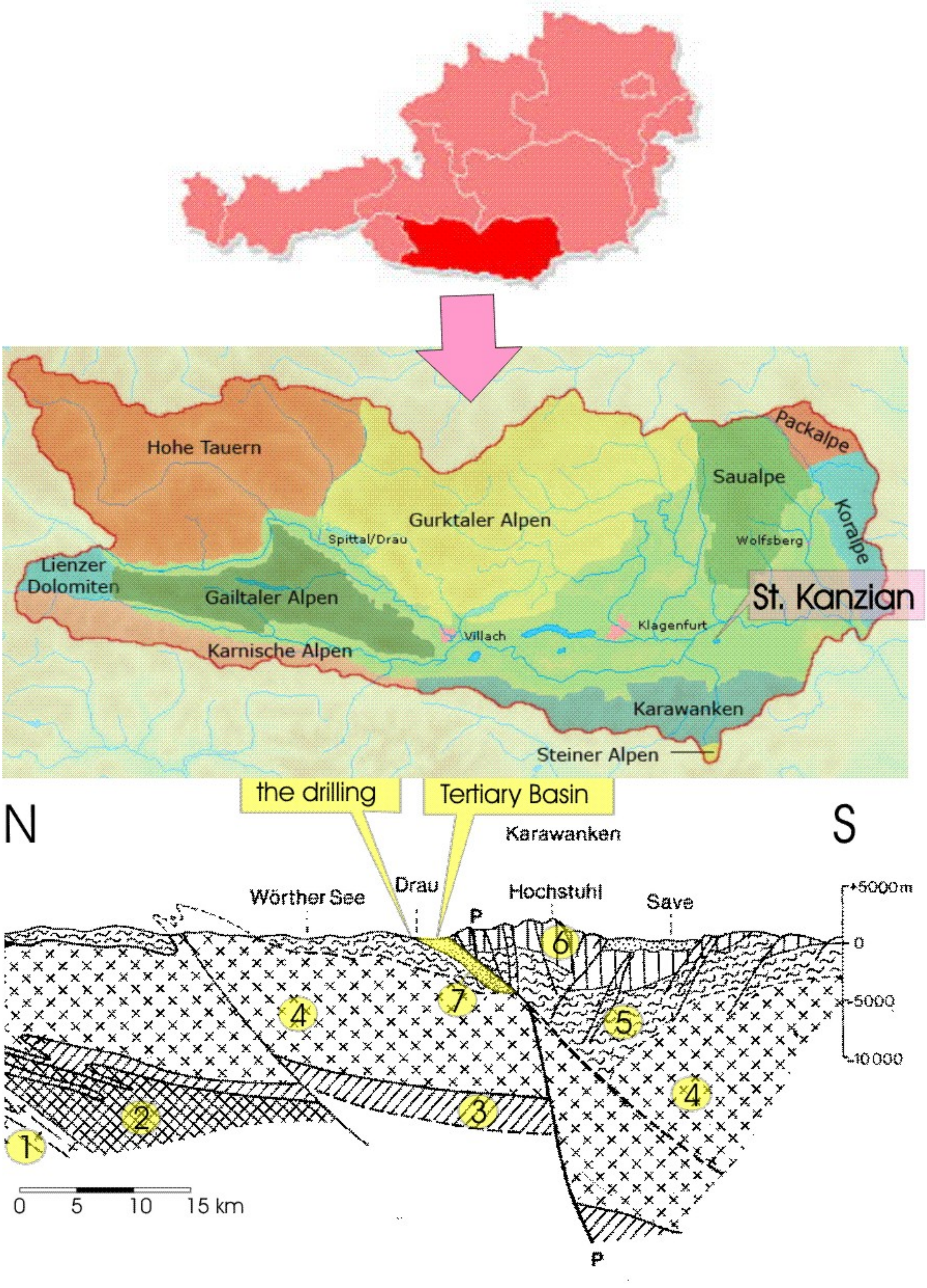

Figure 10: Cross section showing the location of well Kanzian Thermal 1 (taken from OBERHAUSER, 1980)
Pennine: 1 = Central gneiss/metamorphic Paleozoic rocks; 2 = Penninic shales ("Schieferhülle")
Lower Austoalpine Unit: 3 = sedimentary sequence, 4 = crystalline; Upper Austoalpine Unit: 5 = Quartz phyllite, 6 = Southalpine Mesozoic, 7 = Molasse, intromontane tertiary.

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY (Installed capacity)

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2009	1.4	3.8									1.4	3.8
Under construction in December 2009	-	-										
Funds committed, but not yet under construction in December 2009	-	-										
Total projected use by 2015	6	15									6	15

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2009

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe	Annual Energy Produced 2009[3)] GWh/yr	Total under Constr. or Planned MWe
Blumau	Blumau	2001	1		ORC	0.2	1.2	
Altheim	Altheim	2002	1		ORC	1.0	2.0	
Simbach / Braunau	Simbach / Braunau	2009	1		ORC	0.2	0.6	
Total							3.8	

3) Data are for 2009

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2009 (other than heat pumps)

1) I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
H = Individual space heating (other than heat pumps)
D = District heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)
E = Electricity (ORC)

2) Enthalpy information is given only if there is steam or two-phase flow

3) Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.004184 (MW = 10^6 W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

4) Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

5) Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

Note: please report all numbers to three significant figures.

Locality	Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (^{o}C)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Altheim	D, E	100	105	60			18.8	17	101.8	0.2
Geinberg	I, D, B, G	25	105	30			7.8	11	113.5	0.5
Simbach-Braunau	D	74	80	50			9.3	36	141.2	0.5
Obernberg	D	20	80	50			2.5	7	27.3	0.3
St. Martin im Innkreis	D	20	90	50			3.3	10	53.2	0.5
Haag am Hausruck	D	20	86	50			3.0	4	19.7	0.2
Bad Schallerbach	B, D	55	38	15			5.3	30	91.0	0.5
Bad Blumau	B, D, E	30	110	50			7.5	25	197.9	0.8
Bad Waltersdorf	B, D, G	17	63	30			2.3	10	43.5	0.6
Loipersdorf	B	4	61	30			0.5	4	14.3	0.9
Bad Radkersburg	B	5	70	30			0.8	4	21.1	0.8
Fuerstenfeld	D	5	85	50			0.7	3	11.5	0.5
Sebersdorf/Waltersdorf	B	2.5	33	30			0.03	2	08.	0.8
TOTAL		377.5					62.1	162.4	836.8	

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2009

This table should report thermal energy used (i.e. energy removed from the ground or water) and report separately heat rejected to the ground or water in the cooling mode. Cooling energy numbers will be used to calculate carbon offsets.

Report the average ground temperature for ground-coupled units or average well water or lake water temperature for water-source heat pumps

Report type of installation as follows: V = vertical ground coupled (TJ = 10^{12} J)
H = horizontal ground coupled
W = water source (well or lake water)
O = others (please describe)

Report the COP = (output thermal energy/input energy of compressor) for your climate

Report the equivalent full load operating hours per year, or = capacity factor x 8760

Thermal energy (TJ/yr) = flow rate in loop (kg/s) x [(inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.1319
or = rated output energy (kJ/hr) x [(COP - 1)/COP] x equivalent full load hours/yr

Note: please report all numbers to three significant figures

Locality	Ground or water temp. (^{o}C)[1)]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2)]	COP[3)]	Heating Equivalent Full Load Hr/Year[4)]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
No detailed information available; a total number of some 50,000 installations can be assumed by 2009.								
TOTAL								

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2009

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]	-	-	-
District Heating [4]	50.03	602.4	0.5
Air Conditioning (Cooling)	-	-	-
Greenhouse Heating	1.80	29.0	0.5
Fish Farming	-	-	-
Animal Farming	-	-	-
Agricultural Drying[5]	-	-	-
Industrial Process Heat[6]	2.15	31.3	0.7
Snow Melting	-	-	-
Bathing and Swimming[7]	8.87	185.0	0.9
Electricity (ORC)	13.80	133.9	0.7
Subtotal	76.65	981.61	
Geothermal Heat Pumps	600.00	2,880.00	
TOTAL	676.65	3,861.61	

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2005 TO DECEMBER 31, 2008 (excluding heat pump wells)

1) Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1)]	(all)		7			9.5
Production	>150° C					
	150-100° C					
	<100° C					
Injection	(all)					
Total			7			9.5

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2005	1		1	4		4
2006	1		1	4		4
2007	1		1	4		5
2008	1		1	4		5
2009	1		1	4		5
Total	4		4	20		23

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2004) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1990-1994	12.1	1.5	15.5		59	41
1995-1999	44.3	6	19	3	59	41
2000-2004	24.2	1.8	1.5		60	40
2005-2009	14.3	0.9	1.5		60	40