AUSTFUAN GEOTHERMAL UPDATE

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INTRODUCTION

The discussion about the use of geothermal energy started in Austria ***as*** in many other countries following the oil crisis of 1973. In 1975 a general research concept was evaluated hut not until 1985 the first geothermal exploration well was **sunk** in the Styrian basin for the district heating **of** parts of the town of Fürstenfeld. Figure 1 shows the prospective **areas** for the exploitation of geothermal energy in Austria. Although the geological structures are favorable for tapping thermal **waters** for geothermal use in the Vienna basin and the Molasse zone **of** Lower Austria the geothermal exploration was focused **on** the Styrian **basin** and the Molasse basin of Upper Autria. **Since** 1985 ***se***veral wells have been successfully drilled here for thermal waters but their thermal output is only partially used Use for balneological purposes plays a great role and spas and thermal **recreation centers** are of great economic importance especially in southern Austria (federal countries Styria and Burgenland). The efficency of geothermal projects **is** limited by insufficient use of the disposable temperature **range** and the lack of renjection **wells**

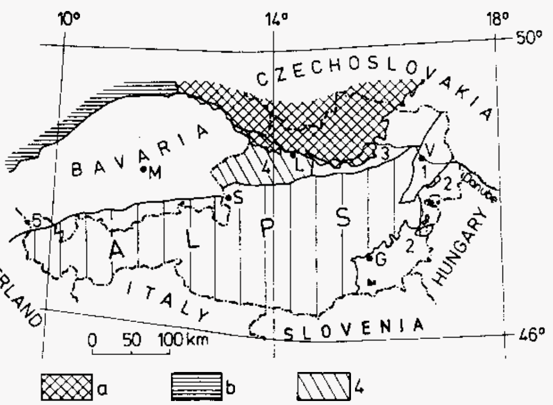

Figure 1 **Geothermal** prospektive **areas** in **Austria**
1 = **Vienna** Basin; 2 = Styrian **Basin and** Landseer Bucht; 3 = Lower Austrian Molasse Basin, 4 – Upper **Austrian** Molasse **basin.** 5 = Rhine Valley in \,omberg; a = Crystallinic **Rocks** ofthe Bohemian Massif, h Franconian Alb; G Graz; L = Linz; M =Munich. V = Vienna

UPPER AUSTRIAN MOLASSE BASIN

The Upper Austrian Molasse basin is a 130 km long part of the Alpine-Carpathian foredeep which extends from Switzerland to Poland. The crystalline rocks ofthe Bohemian massif crop **out** along the basin border in the north and northwest and dip towards the south to form the basement for the overlying sediments. Due to subduction processes rocks ofthe molasse basin **and** its basement continue under the alpine body. The southward dip is locally strengthened by synthetic and antithetic faults, swinging around in the west-east direction The main tectonic activity ceased by the Oligocene The basin **floor** and the tertiary basin filling cover a stratigraphic period from the Carboniferous to the Pliocene

The most important deep aquifer lies in limestones and dolomites of Malmian age which **can** attain thicknesses of 500 m Exposed for a long time on the surfacc carstitication took place Zones of high permeability due to second porosities arc mainly concentrated to NNW-SSE strinking pre-Tertiary faults and the above-mentioned W-E trending faults. **Up** to 1000 meters thick marine Upper Cretaceous sediments overlie in some parts the Malmian carbonates Due to the prevailing tine **clastic** sedimentation they generally do not **exhibit** aquifer properties apart from **some** locally important sandstone horizons

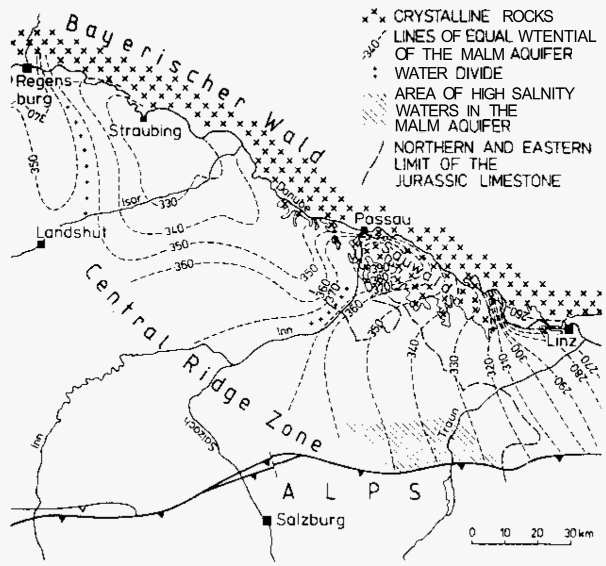

Figure 2 **Potentiometric map** of the Malm Aquifere **in** Upper Austria and Southern Germany; **A** = **well Altheim Ia, S = well Schallerbach.**

Isotopic investigations (J.N ANDREWS ct al , 1987, J E GOLDBRUNNER, 1988) have proved the meteoric origin of the Malm waters Their low mineralisation (1 - 1.5 g/l) is in **a** clear contrast to the high salinity ofthc formation waters ofthe tertiary **basin** filling These waters are oftcn connected with hydrocarbon deposits There is evidence that the recharge **areas** of the Malm aquifer, which is also the main target for geothcrmal exploration in the South German part ofthe Molasse basin takes place at the north eastern part The potentiometric surface indicates **a** W-E to NW- E flow trend in the Upper Austria part of the Malm aquifer. whereas in the neighbouring Bavarian part **tlow** is directed to the north towards the discharge areas of Straubing and Regensburg (Figure 2) In the **Upper** Austrian Molasse **Basin** a discharge area has been identified W **of** Linz where ascending **of** deep scatcd groundwaters causes a thermal anomaly leading to geothermal gradients **as** high as 9° C 100 m at shallow depth. Due to erosion Malm carbonate rocks are not present thcrc, tlow takes mainly place in the highly permeable tertiary basal sands. The well of Schallerbach ("S" in Figure 2) shows a **free** overflow **of** 60 l/s at **a** temperature of 39 °C. The production was used only **far** balneological purposes **for** dccades Since 1990 heat pump installations provide the hcating supply for the spa, the installed thermal power equals 3.5 MW.

In 1989 a gcothermal drilling **was sunk** for establishing a district heating scheme in the small town of Althcim ("A" in Figure 2) **near** the border to Germany. The dcpth ofthe borehole **was 2472** m, the **main** aquifer, fractured limestones and dolomite of Malmian **age were** reached at a depth of 2146 m Stimulation with hydrochloric acid enhanced the free **overflow** to 46 l.s at **a temperature of** 104 ° *C,* the shut-in pressure at the wellhead **at** this lemperature is 4 2 bar, hydraulic conductivity ıs 2 75 * 10^{-5} m/s, the **net** pay of the formation is appr 40 m according to evaluation of borehole logging. The total mineralisation of the sodium-bicarbonate-chloride water is 1 3 g/l **At** the end of 1994 the installed thermal capacity equals 9 6 MW (Table 1), 635 costumers (private houses **and** public buildings) arc geothermall? heated Problems are the insufficient use ofthe thermal **power** resulting ın a return temperature of 60 °C which has **to** he cooled down before feeding it into the **brook** The total thermal output would bc as high as 17 MW thus making the Altheim borehole the most powerful geothermal well in Central **Europe** ın non volcanic areas

At higher flow rates the depression of the potentiometric surface **shows** influences **on** the well of Geinberg, which has a distance of 4 7 km and has its aquifer also in Malm carbonates of the hasin tloor at a similar depth The maximal **flow** at his well ıs 22 l/s (also artesian) at a temperature of 104 °C, **the** geothermal **use** includes heating of 60 private houses and use **in a** dairy **Also** glass houses with **a** total area of **1**5 **ha** are geothermally heated The installed thermal capacity equals 3 2 MW.

THE STYRIAN BASIN

The Styrian basin **is** a hordrr basin ofthe great Hungarian basin Subsidence **took** place ealier than in the Pannonian basin. **At the** surface there ıs no marked topographical boundary beween both basins. **In** the subsurface a ridge zone, called Südburgenländische

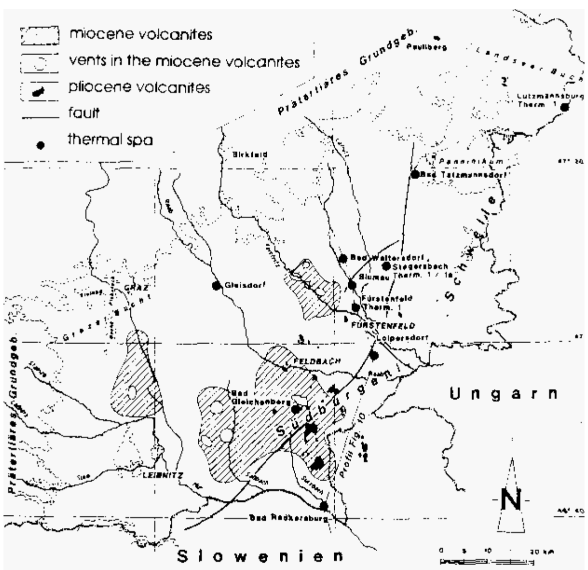

Figure 3. Geological map of the Styrian Basin and the Landseer Bucht showing the localities of the thermal wells.

Schwelle (Figure 3), forms a major geological and hydraulic boundary between the two basins ın the south. In the north, west and southwest the Styrian basin ıs surrounded by **rocks** of the Austro-Alpine crystalline

The Styrian Basın **differs** greatly from the Upper Austrian Molasse basin **in** the CO_2 rich **waters** due to **post** volcanic **activities** The appearence of CO_2 shows some limits **for the** geothermal use by causing technical problems due to corrosion and precipitation of carbonates in high temperature waters after reequilibration with the atmosphere Volcanic activity occured during the Karpatian and lowest Badenian where fault-tectonical events were acompanied **by** an andesitic-dazitic volcanism. Big shield vulcanoes where formed which were later nearly entirely covered by younger **sediments. A** second phase of vulcanic activity occured during the Pliocene/Early pleistocene. Basaltic and nephelinitic lavas have raised through fissure vents; chimneys tilled with tuffitic material **are** common. The post volcanic CO_2-facies ıs frequently linked with **the** younger phase

The use of **waters was** focused **on** the balneological side The number of visitors to the spas ofthe Styrian basin was 1235000 in 1992 This shows the economic importance of the spas for the otherwise agriculturally dominated region From 1985 - 1994 **7** deep boreholes (Table 2) have been drilled for thermal **wafers.** most of them **are** nearly entirely uscd **for** balneological **purposes,** although there **is** some use for heating the **spas** including **the** use **of** heat pumps (Waltersdorf, Loipersdorf, Lutzmannsburg) The installed geothermal **power** equals only 4.8 MW which ıs ın contrast **to** the possible total thermal output of the **wells** which ıs in the order of 40 MW The geothermal reserves accessible at short date have becn shown to be as high as 140 MW (J.E.GOLDBRUNNER et al., 1991) The enhanced heat flow (maximum 100 mW/m^2) is caused by the thinning of the crust In the center ofthe Fürstenfeld basin the crust thickness **was** determined to be only 19 km by **deep** seismic measurements

The main aquifer ıs ın the allochthonous carbonate **rocks** ofthe Graz paleozoic, which form the basin floor in some parts ofthe basin. The locally high permeability is due **to** jointing and fractoning **In** deep parts of the basin the appearence of CO_2 **means** some limititations to the use **of** waters from the carbonate aquifer.

Because ofthe **small number** of boreholes the hydraulic situation of the carbonate aquifer ıs not **known in** detail **In** shallower pans near the northern basin margin **low** mineralized sodium-bicarbonate-chloride water typcs similar to the waters ın the **Upper** Austrian Malm aquifer have been found Their meteoric **origin was proved by** stable **isotope** investigations (D, ^{18}O) **In deeper** parts ofthe basin the waters in the paleozoic aquifer are mixtures of formation waters and meteoric water

Table 1 Installed thermal capacity in the Upper Austrian Molasse Basin and the Styrian Basin by **the** end of 1994

	Well name	maximum production rate (l/s)	temperature at wellhead (°C)	installed capacity by the end of 1994 (MW)
Upper Austrian Molasse basin	Altheim Thermal 1a	46	104	9.68
	Geinberg 1	20	104	3.2
	Schallerbach 1, 2	64	38	3.5
			Total:	**16.3**
Styrian basin	Waltersdorf 1	17	61	2.5
	Loipersdorf 1, 2	9	61	1.5
	Radkersburg 2	20	80	0.8
			Total:	**4.8**

Table 2: Wells drilled in the Styrian Basin since 1985

well name	Fürstenfeld Thermal 1	Tatzmanns-dorf Thermal 1	Stegersbach Thermal 1	Blumau 1a	Lutzmanns-burg Thermal 1	Walters-dorf 2a	Gleisdorf Thermal 1
Year of drilling	1985/86	1988	1989	1989	1990	1990	1990/91
End Depth (m)	3145	896	3200	3045	954	1420	700
Temperature at end depth (°C)	140	39	132	128	43	69	46
Production interval (m)	1525 -1631	697 - 894	832 - 1476	2664 -2800	458- 904	1152 - 1310	204 - 345
Net pay (m)	81	134	135	-	87	-	20
reservoir rocks	sandstones	gravel	sandstones	dolomite	gravel, sandstones	dolomite	sandstones
production rate (l/s)	16	10	4	17	15	40	6
temperature at wellhead (°C)	76	38	52	101	33	65	28
TDS (g/l)	45.2	2.8	2.9	17.7	1.1	1.6	2.1
water type	Na-Cl-J	Na-HCO_3-Cl	Na-HCO_3	Na-HCO_3-Cl-J	Ca-Na-HCO_3	Na-HCO_3-Cl	Na-CaHCO_3
use	salt-production	spa	spa	district heating, spa	spa	spa	spa

The sediments of the tertiary basin filling which can attain a thickness of nearly 3000 m are only in some parts important as thermal aquifers. This is true of the sandstones of high net pay of Middle Badenian age in the center of the Fürstenfeld subsidiary basin (well Fürstenfeld thermal 1). Pumping tests have proved possible production rates as high as 50 l/s. Reinjection is inevitable due to the high salinity (46 g/l) and the formation water character of the fluid. At present the water is only used for salt production for balneological purposes at a low flow rate.

Problems arise from the unilateral use of thermal waters for balneological pusposes and the lack of reinjection. At some sites the production has led to pressure decrease thus showing the need for reinjection measures.

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