Determination of lithologic sections of specific geothermal parameters by well logs in boreholes of the Vienna Basin

Eva Wegerer[1], Godfrid Wessely[2], Gregor Götzl[3]

[1] Department of Applied Geosciences and Geophysics, University of Leoben, Eva.Wegerer@unileoben.ac.at
[2] OMV AG, Exploration and Production, geowes@chello.at
[3] Geological Survey of Austria, Gregor.Goetzl@geologie.ac.at

The Vienna Basin provides a potential for utilizing deep geothermal energy based on tectonic, facial and lithologic features. In reference to the thermal conductivity only a small number of measurement values are available. There exists, however, a huge amount of hydrocarbon well logging in the Vienna Basin. The intention of the investigation was to gain comparative values for the thermal conductivity of various stratigraphic units of the sedimentary fill of the Neogene basin floor as well as the Alpine basement by means of the lithologic properties, porosity and pore content. Electric logs were applied for the Neogene basin fill to determine this parameter. Concerning the higher lithologic variety of the basement a supplementary analytic is required by density-, sonic- and gamma ray logs as well as by cuttings and cores included.

To determine the connection between the various stratigraphic units and the thermal conductivity three specific areas of the Vienna Basin were taken which differ regarding the thickness of the sedimentary basin fill and the position of theAlpine basement and reflect the complex structural build-up of the basin (Fig. 7a). Examples of lithologic profiles and related thermal properties are given from Neogene depression- and elevation areas of the basin choosing the wells Schönkirchen T 32 and Zistersdorf ÜT 2a (WESSELY 2006), where heat can be provided from the Neogene and the basement and the well Laxenburg 2 (WESSELY 1983) where the energy recovery is mainly related to Calcareous Alpine carbonates of the basement. In addition, in the area of the well Laxenburg 2 a thermal anomaly exists (Fig. 7b).

Table 1: sand /clay ratio and the calculated effective thermal conductivities TC(1) (compared with literature values TC(2)) of the well Schönkirchen T 32

Stratigraphy	Sand	Clay	TC(1)	TC(2)
	%	%	[W/m°C]	[W/m°C]
Upper Pannonian	9,4	90,6	1,66	1,97
Middle Pannonian	19,4	80,6	1,92	1,97
Sarmatian	12,4	87,6	1,83	1,96
Buli.-Rot.-Zone	29,8	70,2	2,31	2,40
Sandschaler Zone	11,0	89,0	2,12	2,60
Obere Lagnidenz.	60,0	40,0	2,64	2,20
Adeklaaer Fm.	32,0	68,0	2,89	2,80
Gänserndorfer Fm.	10,5	89,5	2,65	2,85
Bockfließ Fm.	11,4	88,6	2,67	2,59

Tab 4: porosity values versus depth of the formation basis

Depth - formation basis	specific TC-rock composition	medial porosity
500	3,34	0,35
800	3,34	0,30
1150	3,57	0,25
1200	4,22	0,12
1700	3,86	0,25
1900	3,83	0,05
2500	5,03	0,07

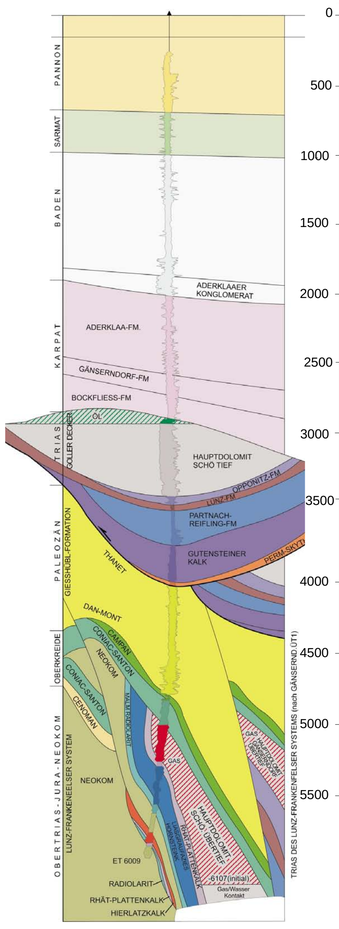

Fig. 1: Stratigraphic profile of the well Schönkirchen T 32

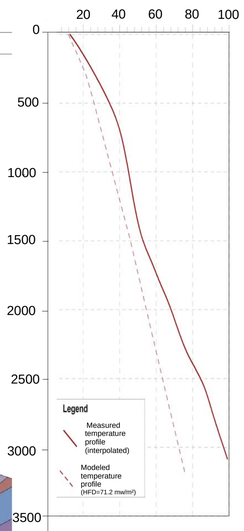

Fig. 2: Temperature profile of the well Schönkirchen T 32

Table 2: sand /clay ratio and the calculated effective thermal conductivities TC(1) (compared with literature values TC(2)) of the well Zistersdorf ÜT 2a

Stratigraphy	Sand	Clay	TC(1)	TC(2)
	%	%	[W/m°C]	[W/m°C]
Upper Pannonian	34,6	65,4	1,91	1,97
Middle Pannonian	46,3	53,7	2,22	1,97
Lower Pannonian	40,9	59,1	2,16	2,23
Upper Sarmatian	29,4	70,6	2,28	2,26
Lower Sarmatian	21,9	78,1	2,66	2,07
Buli.-Rot.-Zone	20,3	29,7	2,85	2,44
Sandschaler Zone	20,2	79,8	2,88	2,61
Obere Lagenidenz.	12,6	87,4	2,76	2,16
Untere Lagenidenz.	13,9	86,1	2,73	2,67

(1) Calcualtion formular for the effective thermal conductivity:

$$\lambda_{eff} = \lambda_s^{(1-\Phi)} \cdot \lambda_f^{\Phi}$$

s...thermal property of the rock composition
f... thermal property of the pore fluid

Porefluid parameter:

fresh water: λ (20 °C): 0,604 W/(mK)
salt water (NaCl 50 g/l): λ (20°C): 0,86 W/(mK)
salt water (NaCl 150 g/l): λ (20 °C): 0,862 W/(mK)

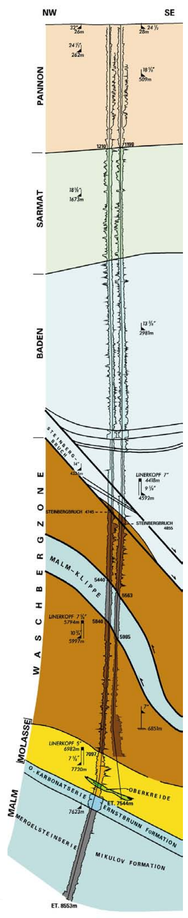

Fig. 3: Stratigraphic profile of the well Zistersdorf ÜT 2a

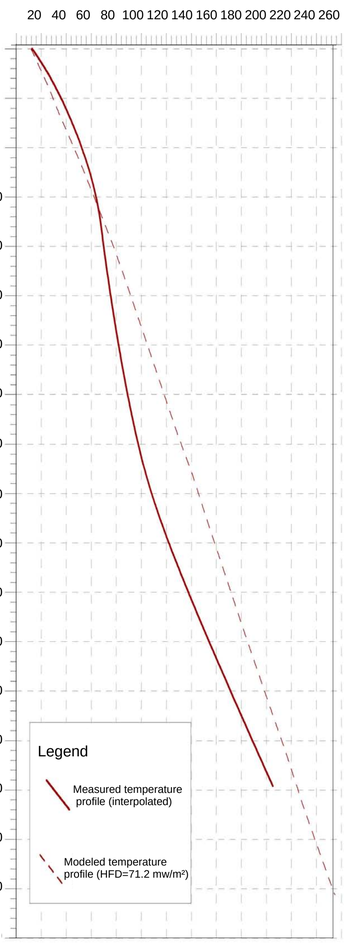

Fig. 4: Temperature profile of the well Zistersdorf ÜT 2a

The thermal conductivity of the different stratigraphic units of the basin fill is calculated first in determining the sand/clay-ratio by electric logs. Table 1 to 3 show the proportional share of sand and clay for the relevant stratigraphic units of the three selected boreholes. On the base of this ratio a lithologic formation value is calculated. The connection to the determination of the relative thermal properties is carried out by lithological specific values (KUTASOV 1999). The varying effects of the pore fluids on the thermal conductivity are integrated by specific porfluid parameter (BECK 1976). For calculation different values of fresh water and saliniferous conditions are integrated. The assignment of the relevant borefluid occurs by information of drill-stem tests from the boreholes. On account of their intense differing thermal properties compared with the matrix the porefluids have a considerable influence on the effective thermal conductivity of a sediment layer.

On the fundamental assumption of anisotrope conductivity and pore distribution within the matrix the thermal lithologic properties are calculated by geometric means (SALCHER & GÖTZL 2007). For calculating the effective thermal conductivity equation 1 is applied. The depth relevant porosity values are shown in Table 4. The determined effective thermal conductivities are facing literature values (SCHÖN 1983) and are shown in Table 1 to 3. In the Calcareous Alpine basement the Hauptdolomit units, taped at the wells Schönkirchen T 32 and Laxenburg 2 were compared according to the thermal properties. The log analysis and the inclusion of lithologic and tectonic information out of the cores and cuttings showed in relation more favourable thermal properties for this formation in the borehole Laxenburg 1 in comparison to Schönkirchen T 32.

Interpretation and discussion:
The analysis points out a relationship between the stratigraphic-lithological profiles and the values of thermal conductivity and according to their depth position it enables the calculation of the quantity of the recoverable energy. In general the thermal conductivity increases with the depth due to compaction of the sedimentary sequences (Fig. 8). Consequently, determination of lithology, compaction, porosity and pore content by analysing electric logs provides representative values for the effective thermal conductivity of the Neogene Vienna Basin. This method can be applied if measured laboratory values are only scattered.

Table 3: sand /clay ratio and the calculated effective thermal conductivities TC(1) (compared with literature values TC(2)) of the well Laxenburg 2

Stratigraphy	Sand	Clay	TC(1)	TC(2)
	%	%	[W/m°C]	[W/m°C]
Middle Pannonian	21,6	78,4	1,86	1,97
Lower Pannonian	18,9	81,1	1,83	1,97
Upper Sarmatian	15,9	84,1	1,81	1,96
Lower Sarmatian	32,3	76,7	1,96	2,07
Buli.-Rot.-Zone	37,5	62,5	2,02	2,44
Sandschaler Zone	38,5	61,5	2,03	2,61

	Laxenburg 2	Schönkirchen T32	Zistersdorf ÜT 2a	measurment values
	[W/m°C]	[W/m°C]	[W/m°C]	
Buli.-Rot.Zone	2,02	2,31	2,64	2,46
Sandschaler Zone	2,02	2,12	2,88	2,88
Upper Lagenidenzone		2,64	2,76	2,70

Fig. 8: Correlation between depth and thermal conductvity

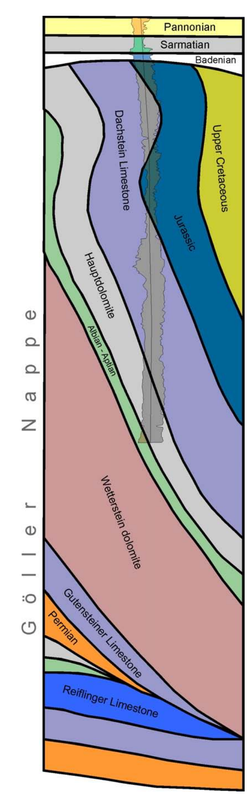

Fig. 5: Stratigraphic profile of the well Laxenburg 2

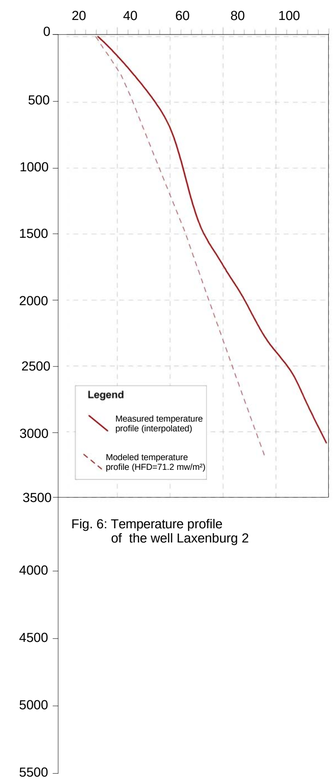

Fig. 6: Temperature profile of the well Laxenburg 2

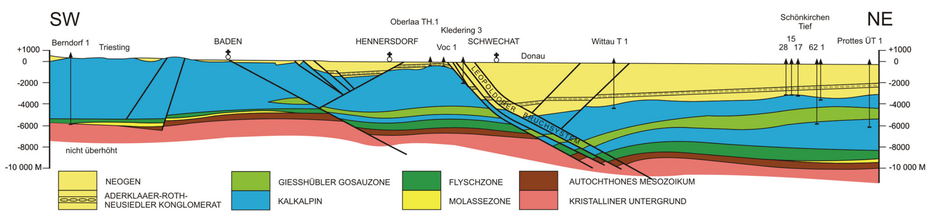

Fig. 7a: Elevation and depression zones of the Vienna Basin

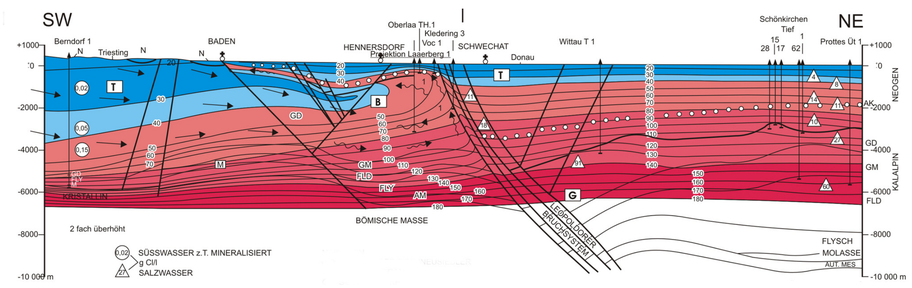

Fig. 7b: Temperature and hydrodynamic of the Vienna Basin

References

KUTASOV I.M. (1999): Applied Geothermics for Petroleum Engineers, Development in Petroleum Sciences Vol. 48, Elsevier.

SALCHER B., GÖTZL G. (2007): Deep Heat Mining in the Austrian Alps - A preliminary Look on Possibilities and Limitations, Proceedings Thirty - Second Workshop on Geothermal Reservoir Engineering, Stanford, California, January 22 -24, 2007.

SCHÖN J. (1983): Petrophysik, Akademie Verlag, Berlin.

WESSLEY, G. (1983): Zur Geologie und Hydrodynamik im südlichen Wiener Becken und seinen Randzonen. - Mitt. Österr. Geol. Ges., 76, 27-68, 8 Taf., Wien.

WESSELY, G. (2006): Geologie der österreichischen Bundesländer. Niederösterreich. - Geologische Bundesanstalt, Wien.