Near surface geothermal energy use in Schleswig-Holstein
about 4000 drillings for ground heat exchanger are reported in Schleswig-Holstein
Hot topics in Schleswig-Holstein:
  - thermal underground properties
  - length of ground heat exchanger
  - effectivity of heat pump
  - approach to grouting control
  - groundwater protection
near surface geothermal energy use in Schleswig-Holstein

thermal parameter of the underground
thermal conductivity
heat capacity

100 – 200 m
typical composition of the underground in Schleswig-Holstein

mixed layering of sand, till clay, sometimes also chalk

- sand
- till
- clay
- chalk or caprock
thermal conductivities after VDI 4640, mean values

<table>
<thead>
<tr>
<th>Material</th>
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<tr>
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<td>saturated sand</td>
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the problem: data scattering

thermal conductivities after VDI 4640, range of values

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closer to reality
near surface geothermal energy use in Schleswig-Holstein

2 drillings from southern Schleswig-Holstein (Nützen, Kreis Segeberg)

Schlenzek 2010

thermal conductivity of till similar to thermal conductivity of sand
thermal conductivity for composite material

\[ \lambda = \prod \lambda_i^{n_i} = \lambda_S^{(1-\phi)} \cdot \lambda_F^\phi \]

geometric mean

rock matrix pore fluid

quartz 6.5 ... 7.2 W/mK
water 0.6
air 0.025
porosity (=water content) of our sedimentary material

~ 30%

~ 20%

~ 40%
- Petrographie-Log

petrography – logs showing the volume contents of sand, clay and pore water

case of water sand clay

till sand
Petrographie-Log

calculation of synthetical hydraulic conductivities:

\[ \lambda_{\text{se} \text{dim} \text{ent}} = \lambda_{\text{water}}^{n_{\text{water}}} \cdot \lambda_{\text{quartz}}^{n_{\text{quartz}}} \cdot \lambda_{\text{clay}}^{n_{\text{clay}}} \]

using:

\[ \lambda_{\text{water}} = 0.5 \text{ W/(m*K)} \]
\[ \lambda_{\text{quartz}} = 7.0 \text{ W/(m*K)} \]
\[ \lambda_{\text{clay}} = 2.9 \text{ W/(m*K)} \]
the thermal conductivity of till is exceeding the thermal conductivity of saturated sand
thermal conductivities of sedimentary deposits

**we use**
- sand: 2.4 W/(mK)
- till: 2.4 W/(mK)
- clay/silt: 1.7 W/(mK)
- chalk: 1.6 W/(mK)
- unsaturated material: 0.4 W/(mK)
near surface geothermal energy use in Schleswig-Holstein

thermal conductivities of sedimentary deposits

we use

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calculation of effective thermal conductivities using drilling results and depth to watertable

in progress:

geothermal planning maps
near surface geothermal energy use in Schleswig-Holstein

e.g. planning map for the region Ellerdorf south of Kiel

boreholes in the region Ellerdorf

Anja Wolf
LLUR (2011)

drillings

- water
- geothermal

interpolation of thermal conductivities from drilling results
depth to groundwater in the region Ellerdorf

thickness of the unsaturated layer, low thermal conductivity

Anja Wolf
LLUR (2011)
near surface geothermal energy use in Schleswig-Holstein

combining both: effective thermal conductivity

Anja Wolf
LLUR (2011)
effective thermal conductivity for drillings of 100 m length

→ data base for the design of ground heat exchanger
our dream (partly in progress): data bank of regionalized thermal conductivities for sand, till and clay

Border crossing cooperation would be nice!!
Just an idea:

Can we use geophysics to predict the thermal conductivity of the ground?

e.g. using electrical resistivities…….
so we can establish a relation of electrical resistivity and thermal conductivity
Airborne EM: large scale resistivity mapping

- 1.6 W/mK
- 2.4 W/mK
- 0.8 W/mK

Resistivity distribution along the flightline
near surface geothermal energy use in Schleswig-Holstein

Interreg project BURVAL: mapping of buried valleys

Results of BGR-HEM survey: resistivity distribution at 0 m bsl
average thermal conductivities down to 70 m, calculated from airborne EM resistivity distribution.
near surface geothermal energy use in Schleswig-Holstein

average thermal conductivities down to 70 m

disturbed signals in urban areas
average thermal conductivities down to 70 m

disturbed signals in urban areas – but here we have a higher density of drillings
Large areas of Denmark (and to a minor extent Schleswig-Holstein) are covered with airborne EM resistivity results here e.g. the North Sea island of Föhr.

Is this a good database for geothermal mapping?
Grouting control: is the borehole completely filled with cement??
near surface geothermal energy use in Schleswig-Holstein

- replaced drill mud
- grout injection tube
- ground heat exchanger

grouting suspension

weight

cavities left?
or has the borehole never been filled with cement?
Cooperation project:
BLM Storkow
TU Berlin
LLUR Flintbek

is a grouting control possible using passive gamma ray techniques?

near surface geothermal energy use in Schleswig-Holstein

simulated bore hole

filled with different grouting material

ground heat exchanger

measuring the gamma ray activity inside the ground heat exchanger tube

special borehole equipment developed by BLM
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background gamma-effect of the simulated claylayer

water instead of cement

cement with circonium sand added (slightly gamma active)

simulated incomplete filling

ground heat exchanger

the incomplete filling can be detected despite the background radiation of the clay.

but: the cement must be slightly radioactive
That works fine in the backyard of the BLM company. The next step – when the mini gamma equipment is operable: field tests under different geological conditions in Schleswig-Holstein.
brandnew:

Guidelines for near surface geothermal energy use in Schleswig-Holstein
near surface geothermal energy use in Schleswig-Holstein
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