Landesamt für Landwirtschaft, Umwelt
und ländliche Räume Schleswig-Holstein
- Geologischer Landesdienst -

Near surface geothermal energy use in Schleswig-Holstein

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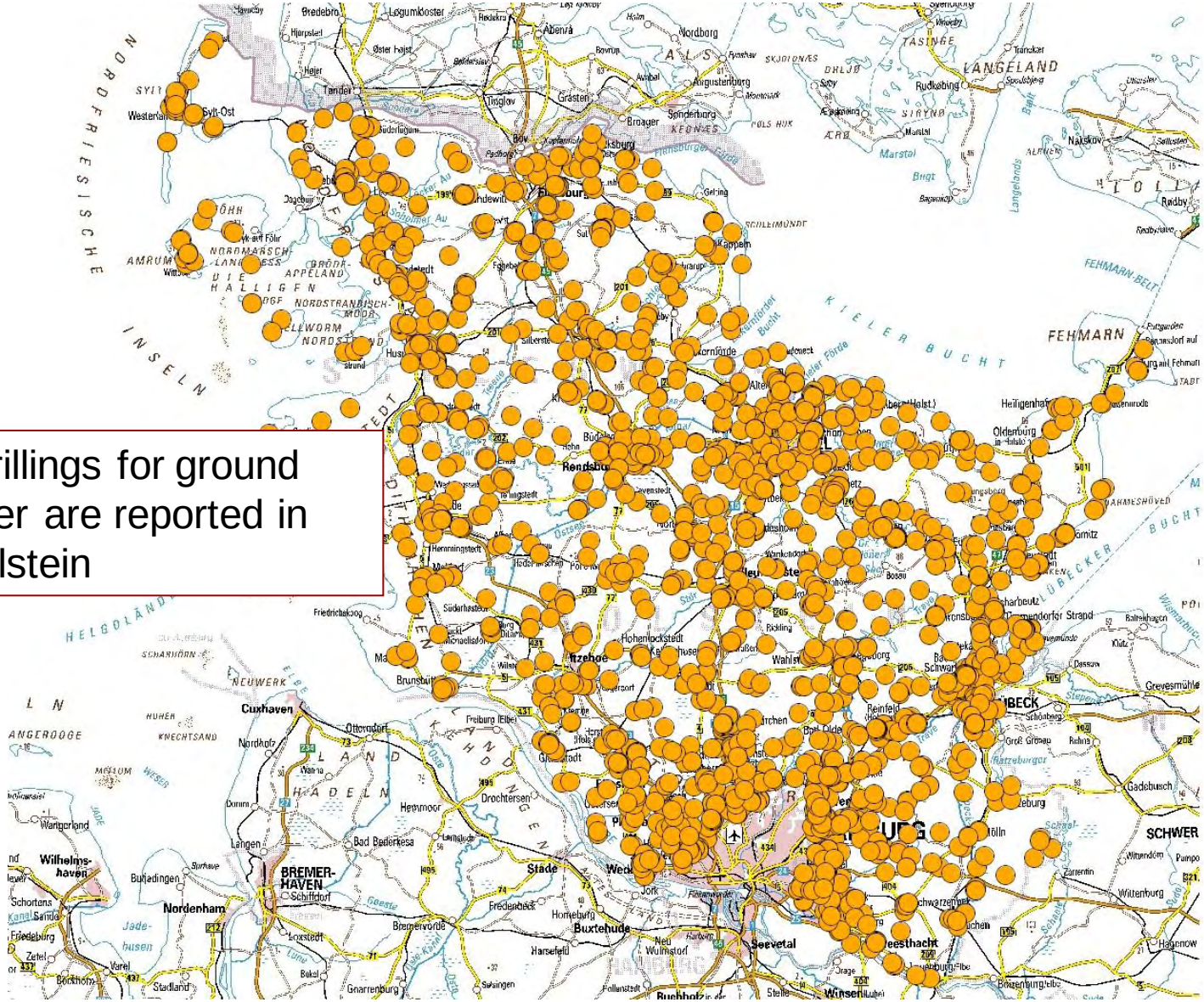

about 4000 drillings for ground heat exchanger are reported in Schleswig-Holstein

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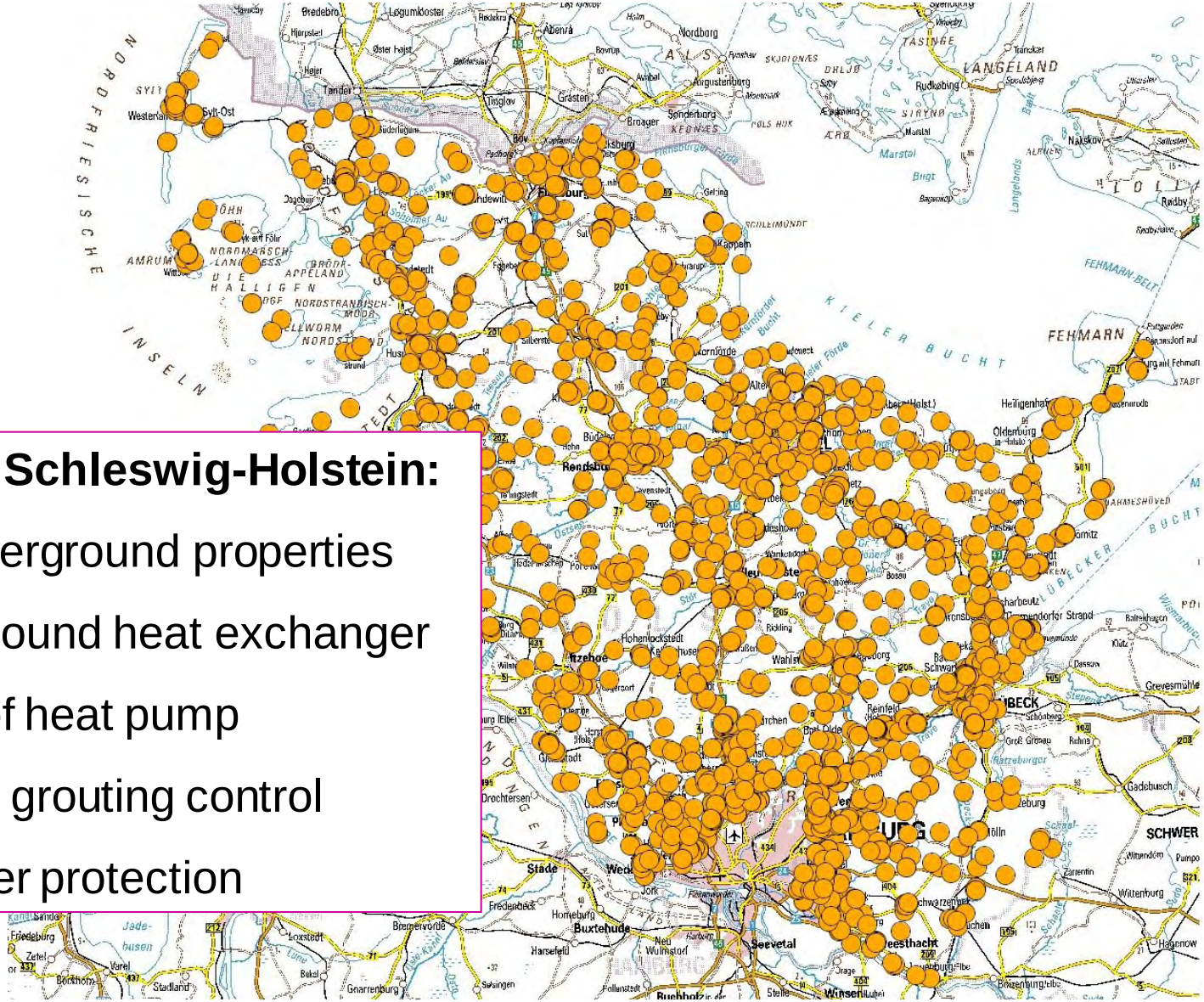


Hot topics in Schleswig-Holstein:

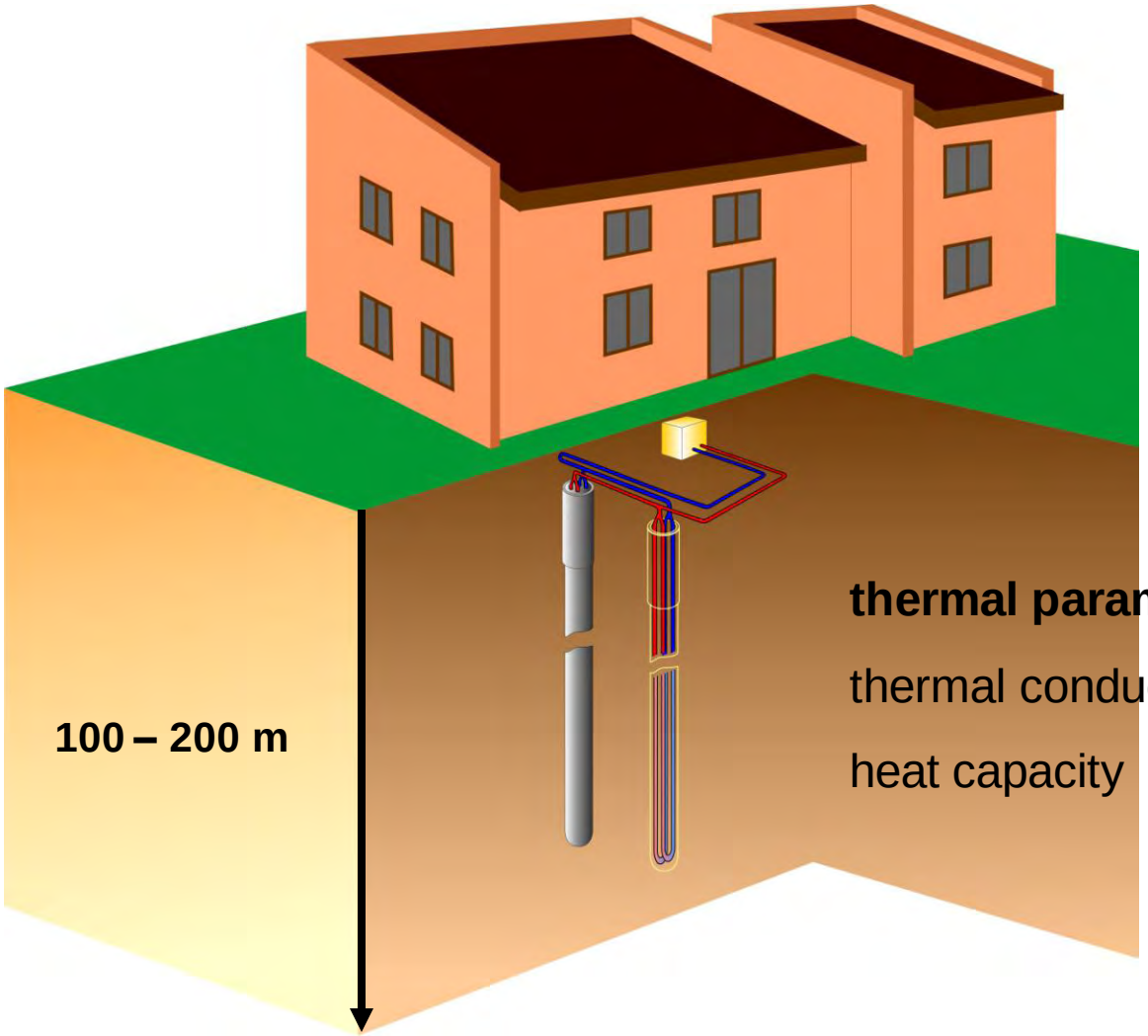
thermal underground properties

→ length of ground heat exchanger

→ effectivity of heat pump

approach to grouting control

→ groundwater protection



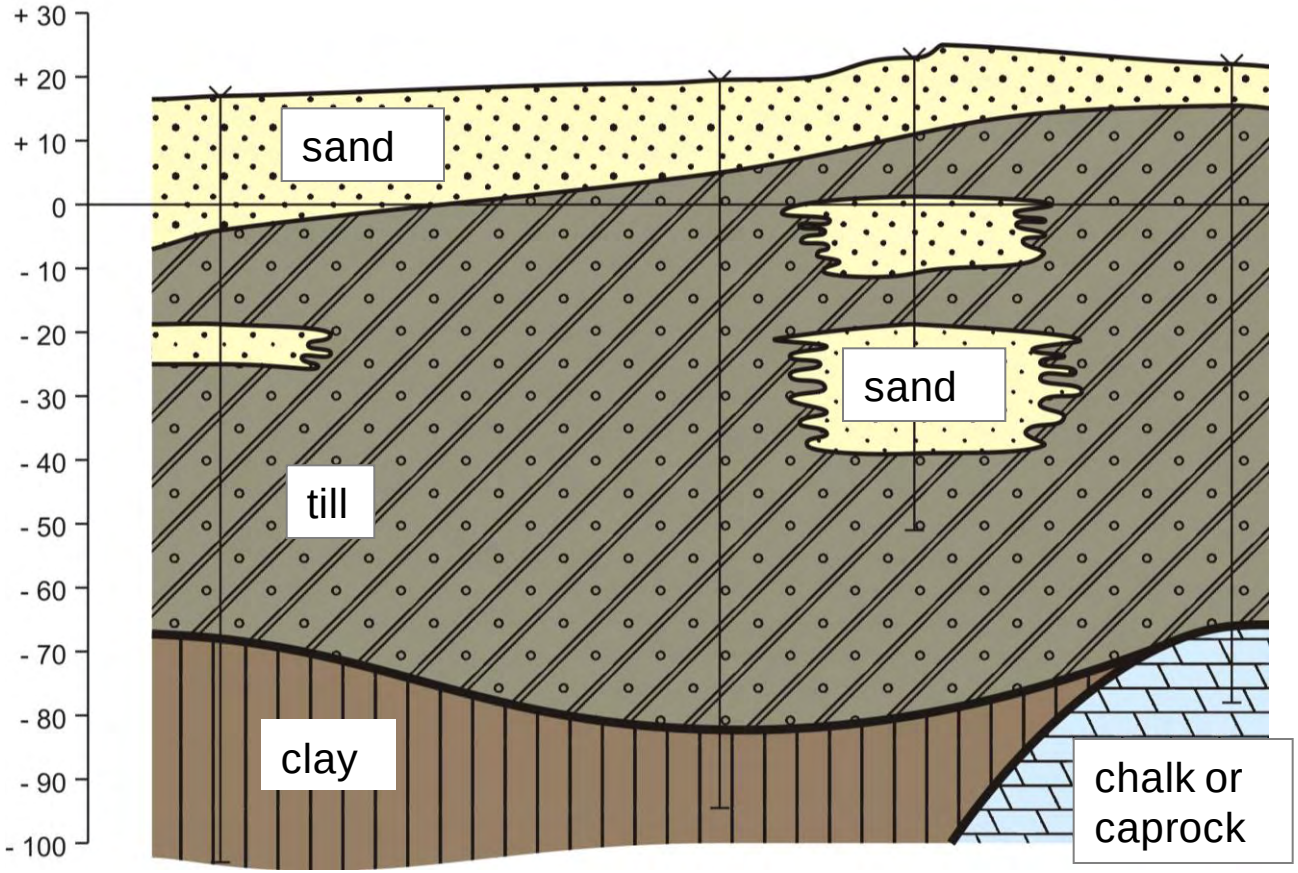
thermal parameter of the underground

thermal conductivity

heat capacity

typical composition of the underground in Schleswig-Holstein

mixed layering of sand, till clay, sometimes also chalk



thermal conductivities after VDI 4640, mean values

dry material	0.4	W/mK
saturated sand	2.4	
till	2.0	
clay, silt	1.7	

the problem: data scattering

thermal conductivities after VDI 4640, range of values

dry material	0.4 – 0.5	→ 0.4 W/mK
saturated sand	1.7 – 5.0	→ 2.4
till	1.0 – 2.5	→ 2.0
clay, silt	0.9 – 2.3	→ 1.7

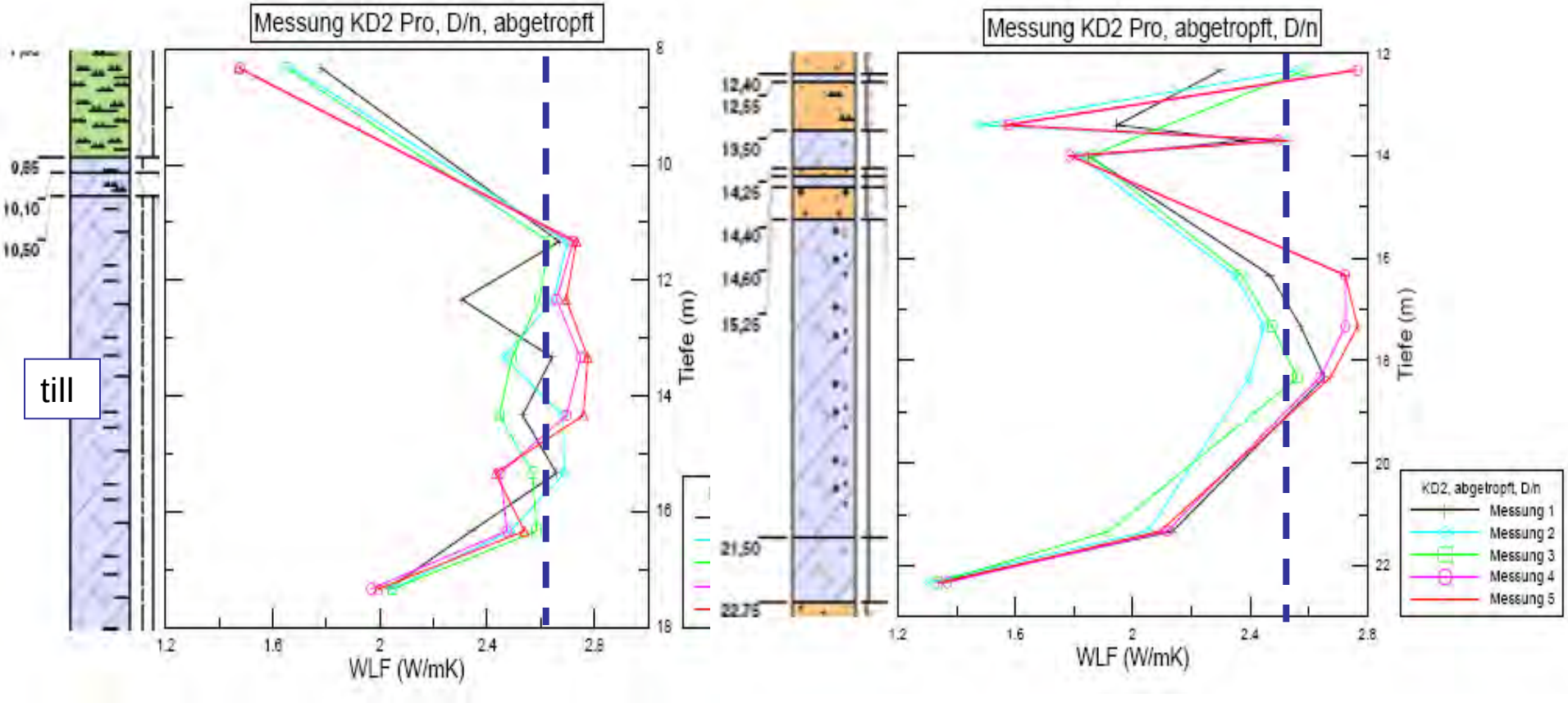
the problem: data scattering

thermal conductivities after VDI 4640, range of values

dry material	0.4 – 0.5	→ 0.4 W/mK
saturated sand	1.7 – 5.0	→ 2.4
till	1.0 – 2.5	→ 2.0
clay, silt	0.9 – 2.3	→ 1.7

closer to reality

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



Schlenzek 2010

thermal conductivity of till similar to thermal conductivity of sand

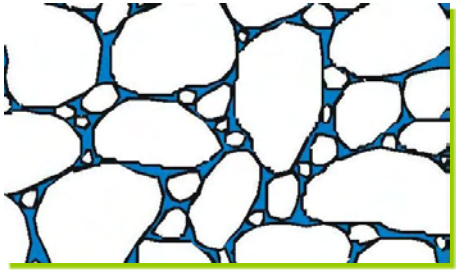
thermal conductivity for composite material

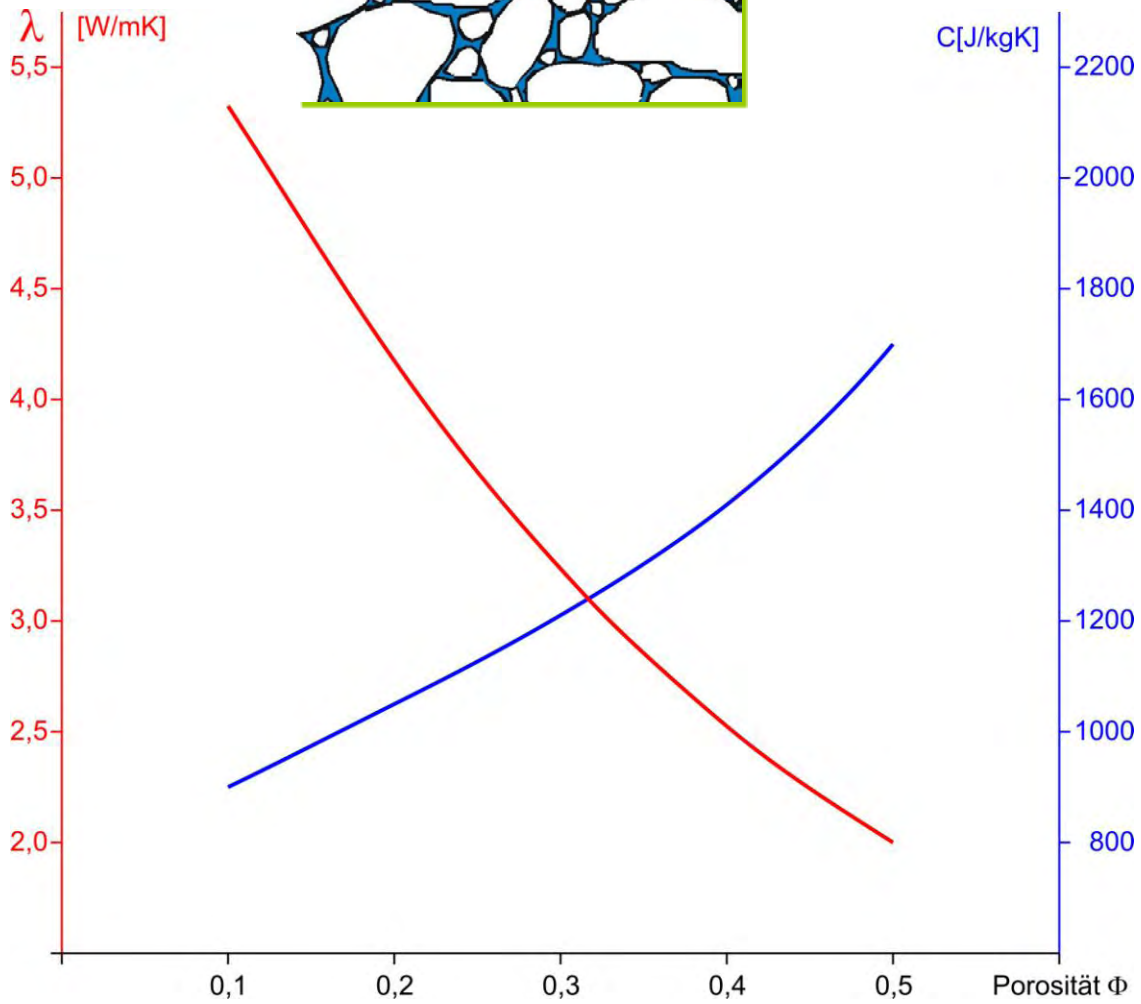
$$\lambda = \prod \lambda_i^{n_i} = \lambda_S^{(1-\phi)} \cdot \lambda_F^{\phi}$$

geometric mean

rock matrix

pore fluid

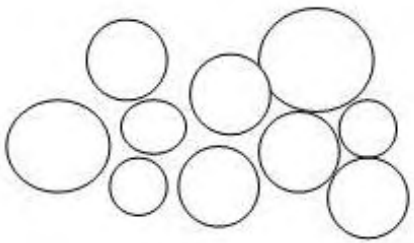




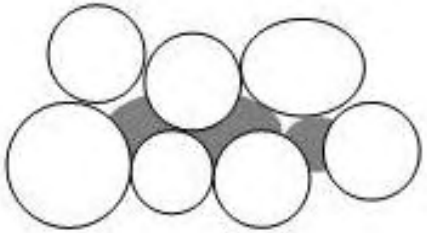
quartz	6.5	...	7.2 W/mK
water	0.6		
air	0.025		

porosity (=water content) of our sedimentary material

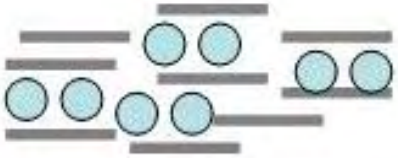
~ 30%

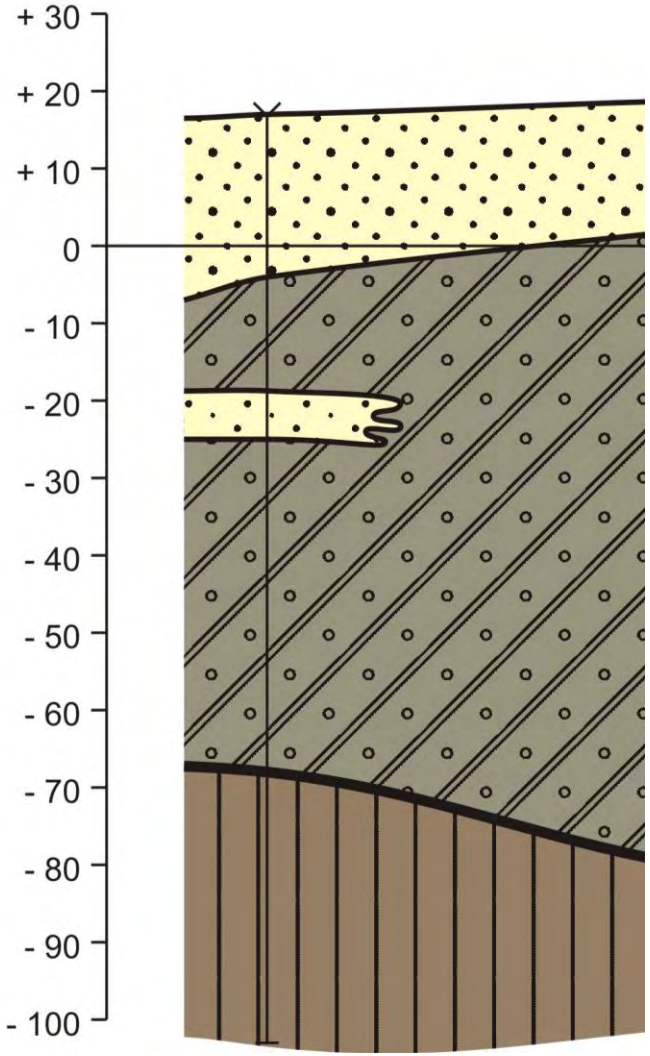


~ 20%

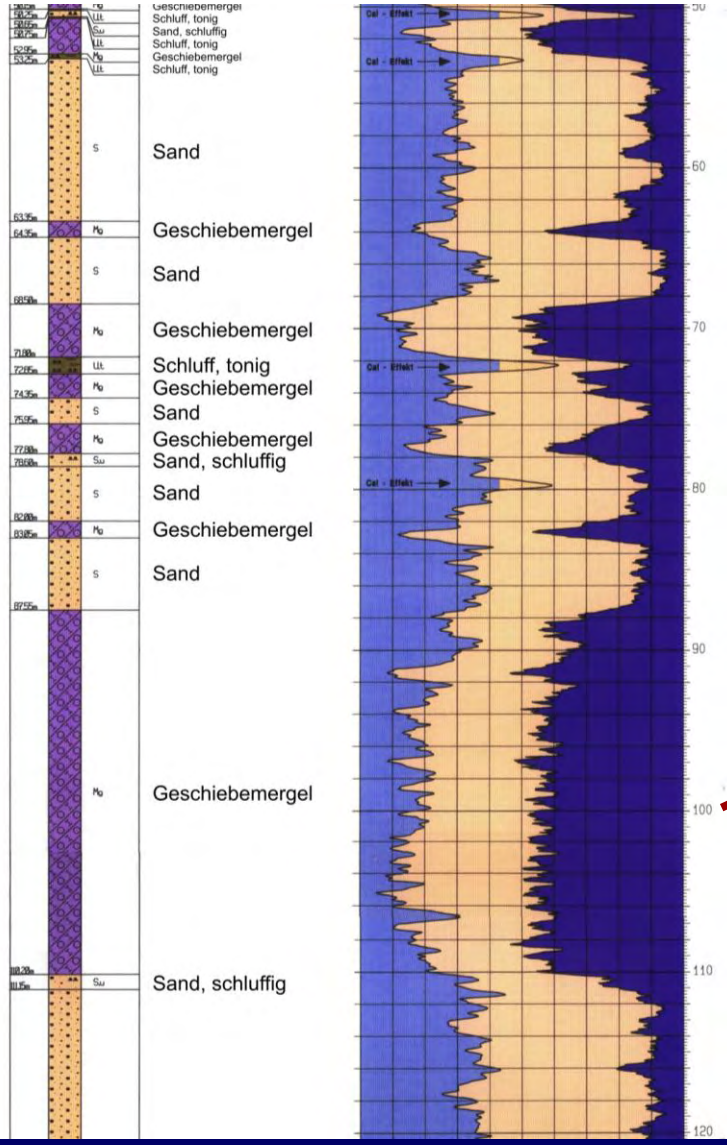


~ 40%

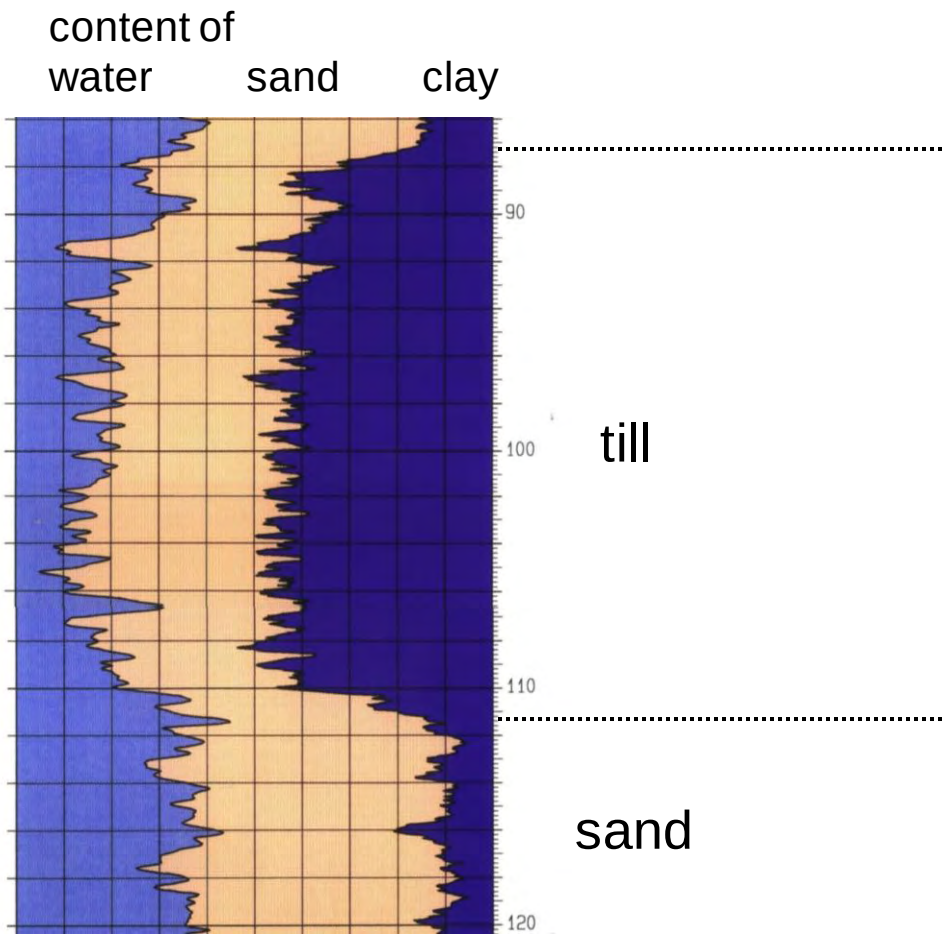




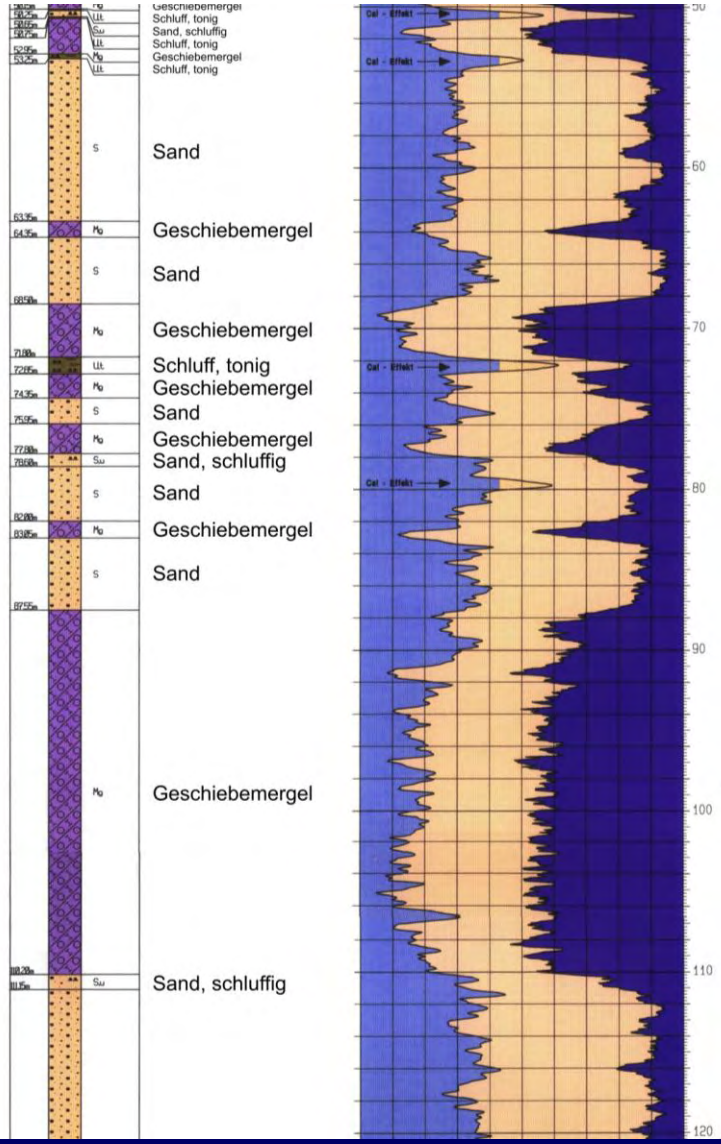
- Petrographie-Log



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



- Petrographie-Log



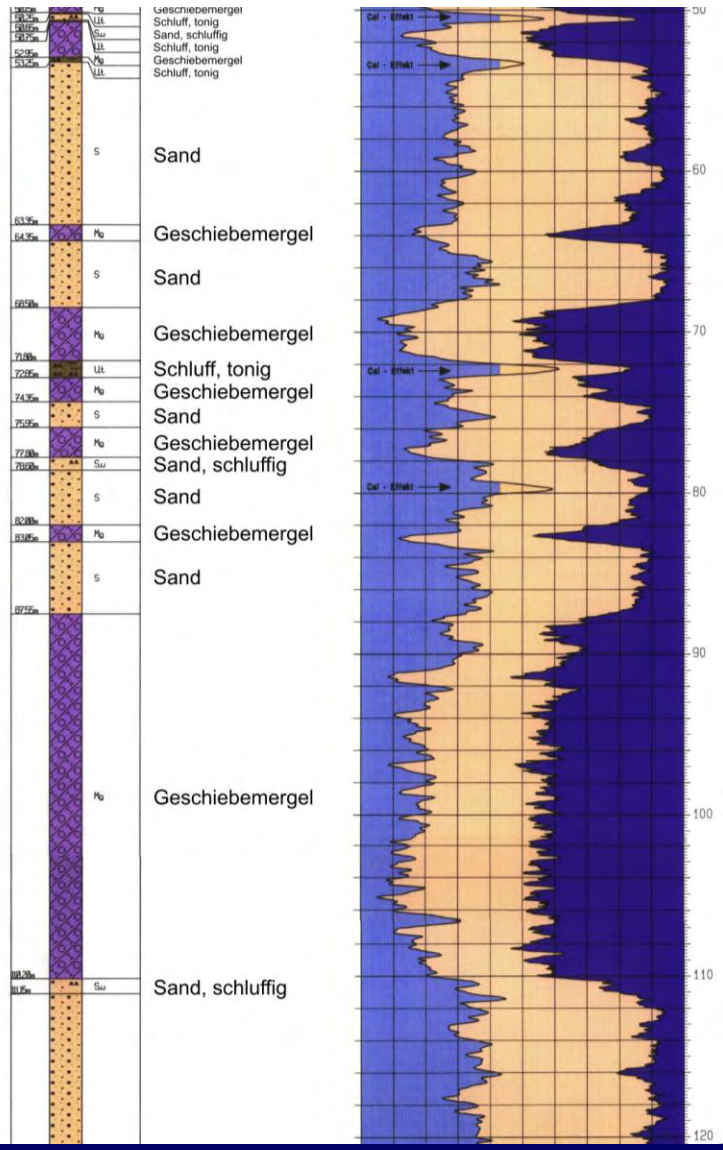
calculation of synthetical hydraulic conductivities:

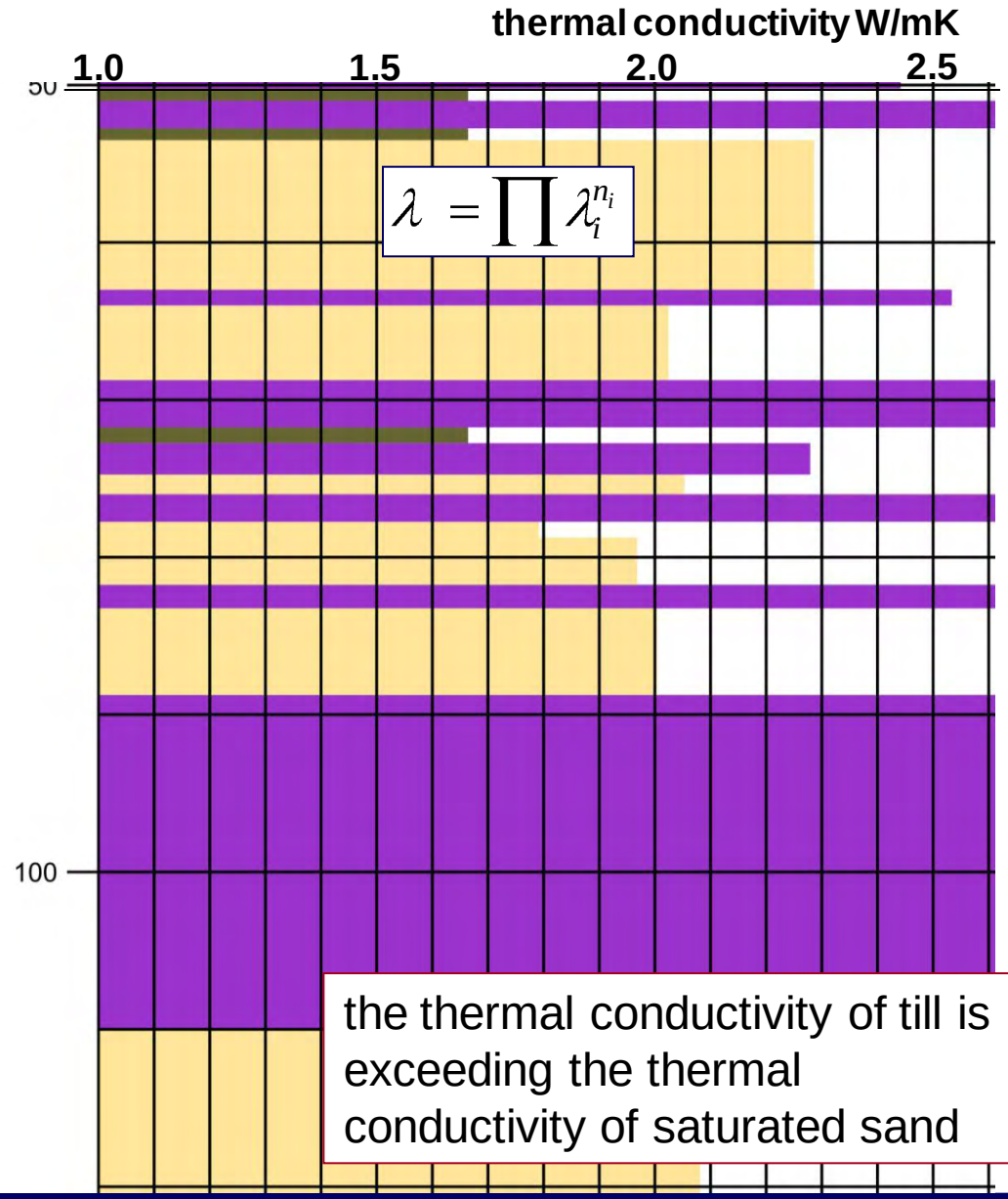
$$\lambda_{sediment} = \lambda_{water}^{n_{Wasser}} \cdot \lambda_{quartz}^{n_{Quarz}} \cdot \lambda_{clay}^{n_{Ton}}$$

using:

λ_{water} = 0.5 W/(m*K)
λ_{quartz} = 7.0 W/(m*K)
λ_{clay} = 2.9 W/(m*K)

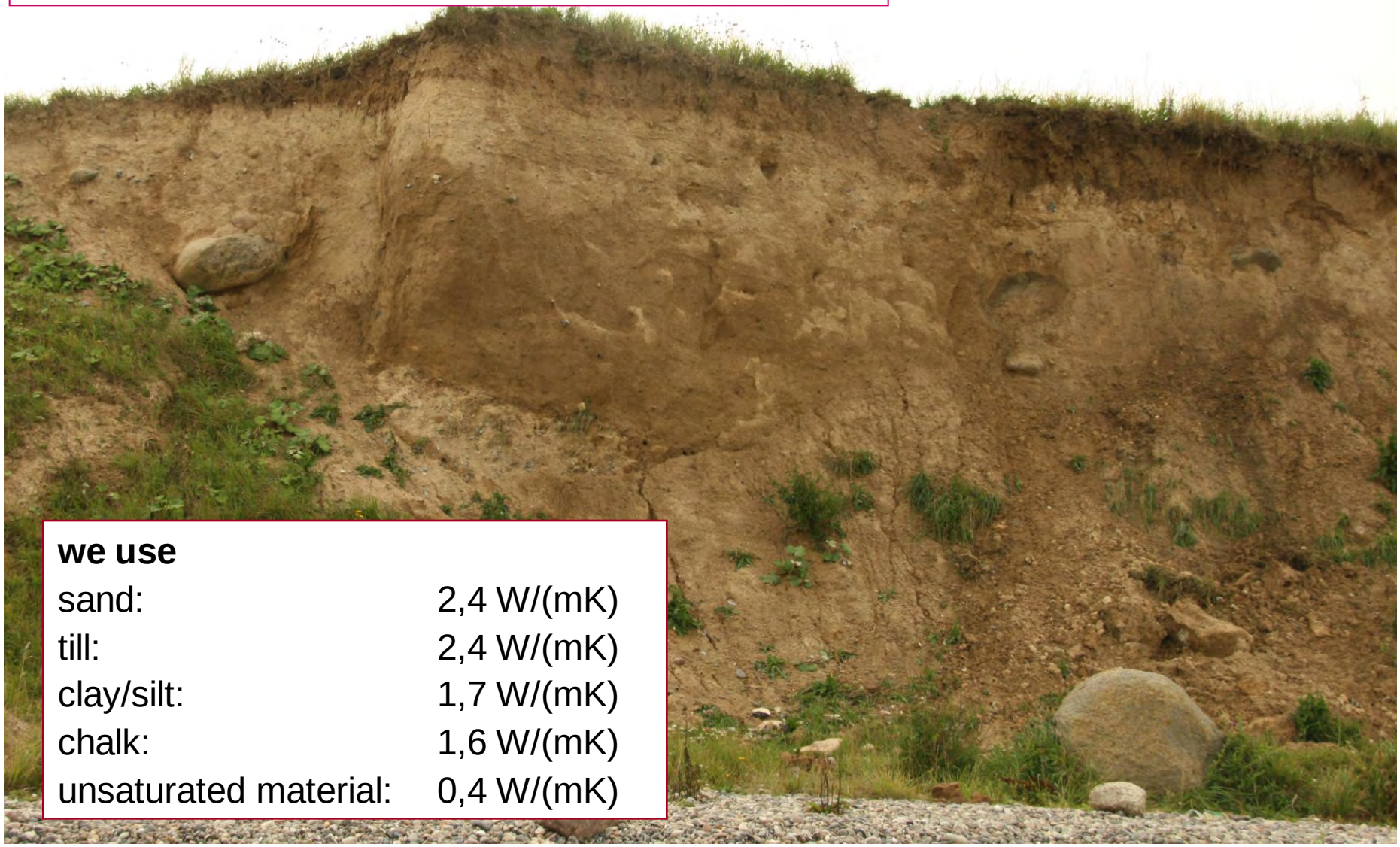
- petrography-log





the thermal conductivity of till is exceeding the thermal conductivity of saturated sand

thermal conductivities of sedimentary deposits

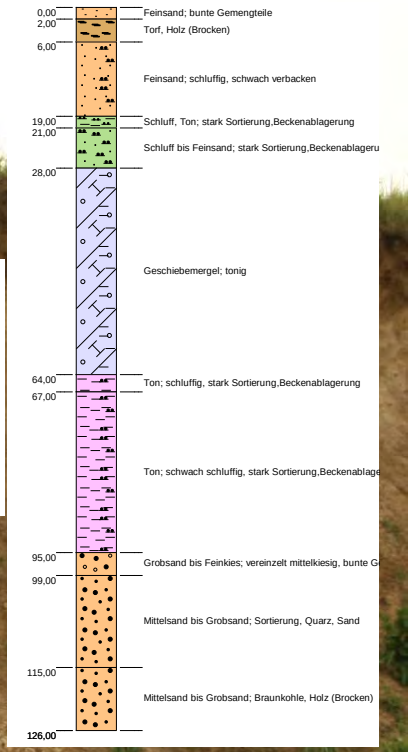


we use

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)

thermal conductivities of sedimentary deposits

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



we use

sand:	2,4 W/(mK)
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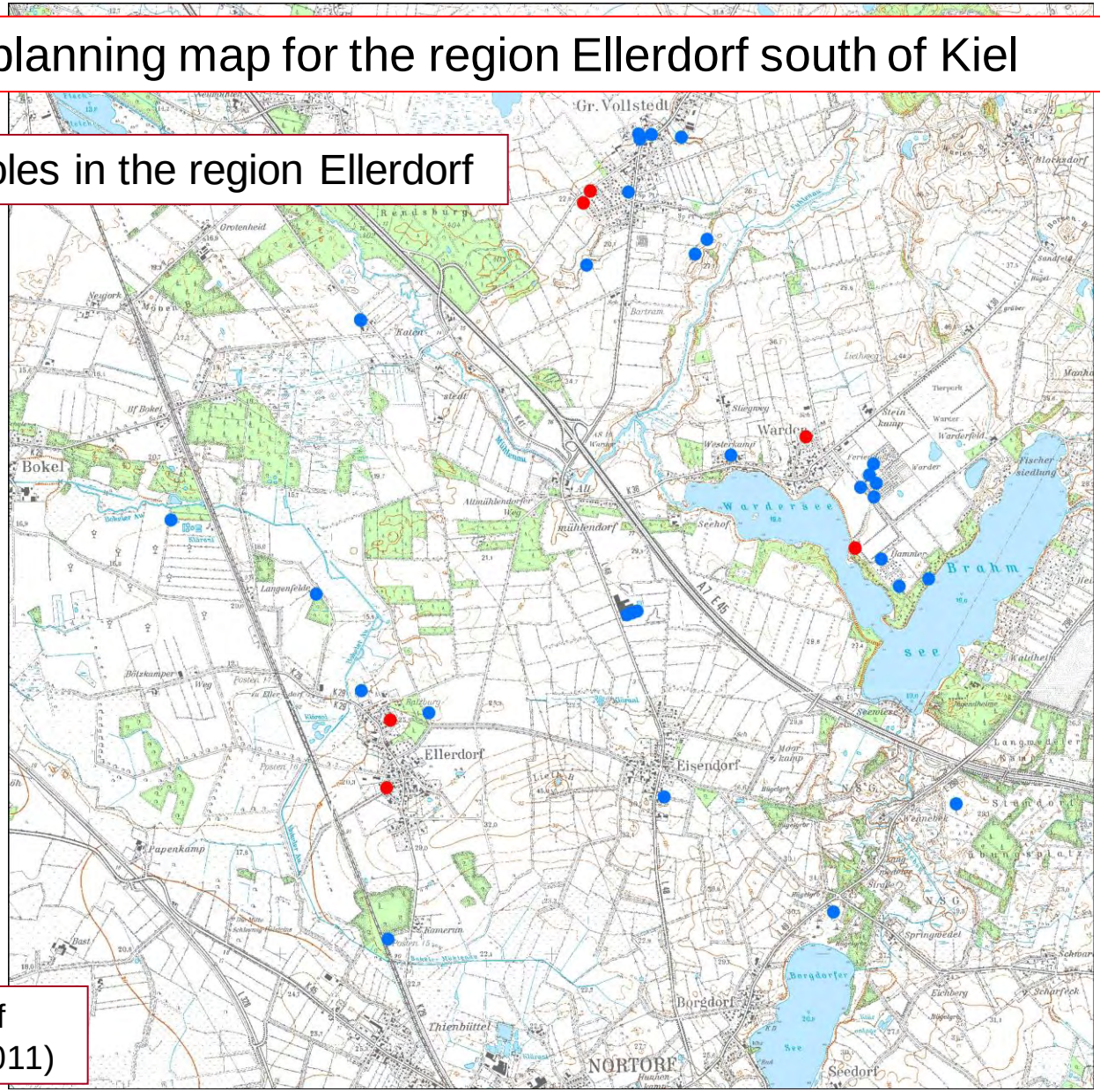
unsaturated material:	0,4 W/(mK)

in progress:

geothermal planning maps

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

boreholes in the region Ellerdorf



drillings

- water
- geothermal

interpolation of thermal conductivities from drilling results

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LLUR (2011)

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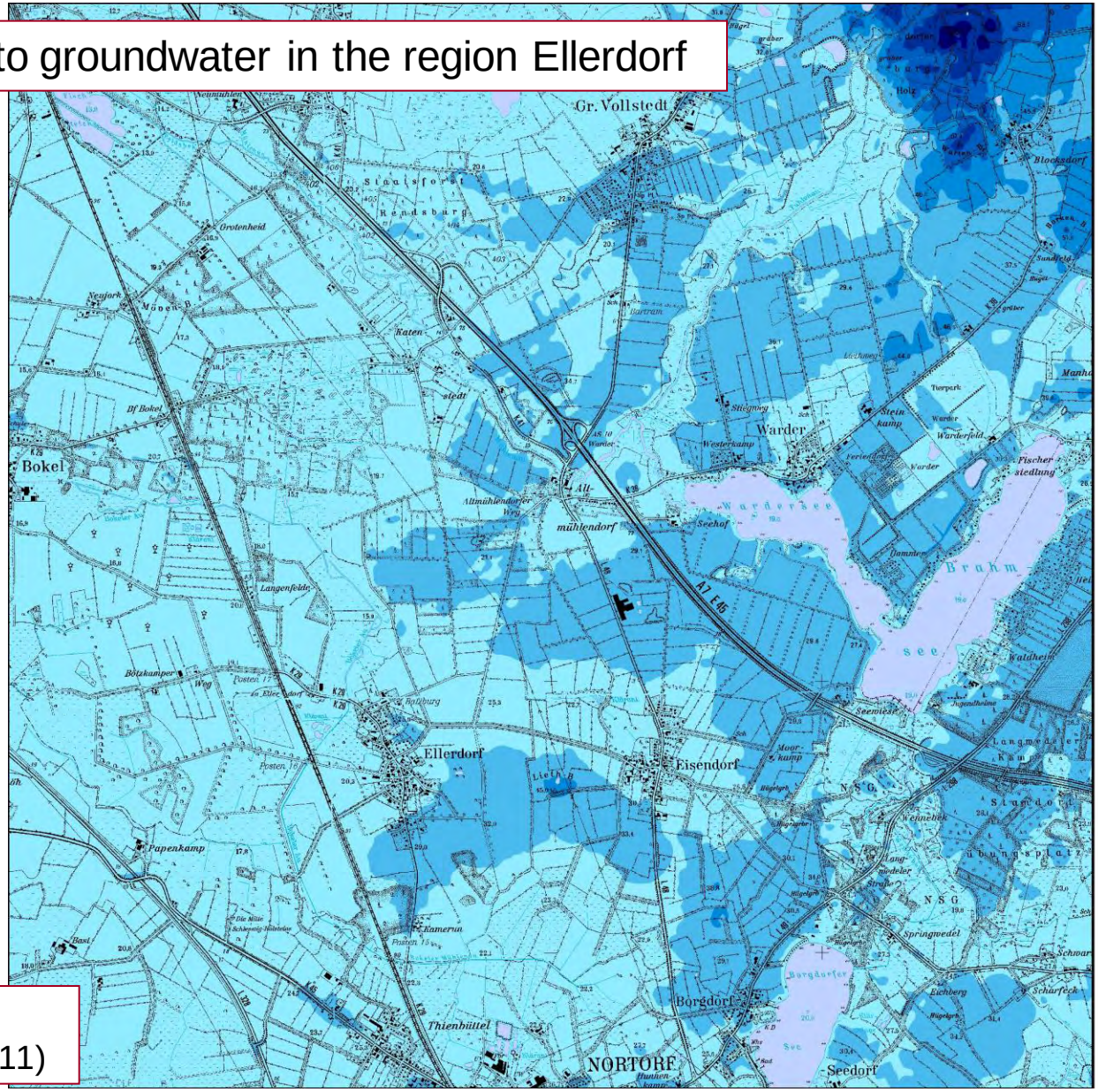
- Geologischer Landesdienst -

depth to groundwater in the region Ellerdorf



thickness of the unsaturated layer, low thermal conductivity

Grundwasserflurabstand

- -1 - 0
- 1 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 50

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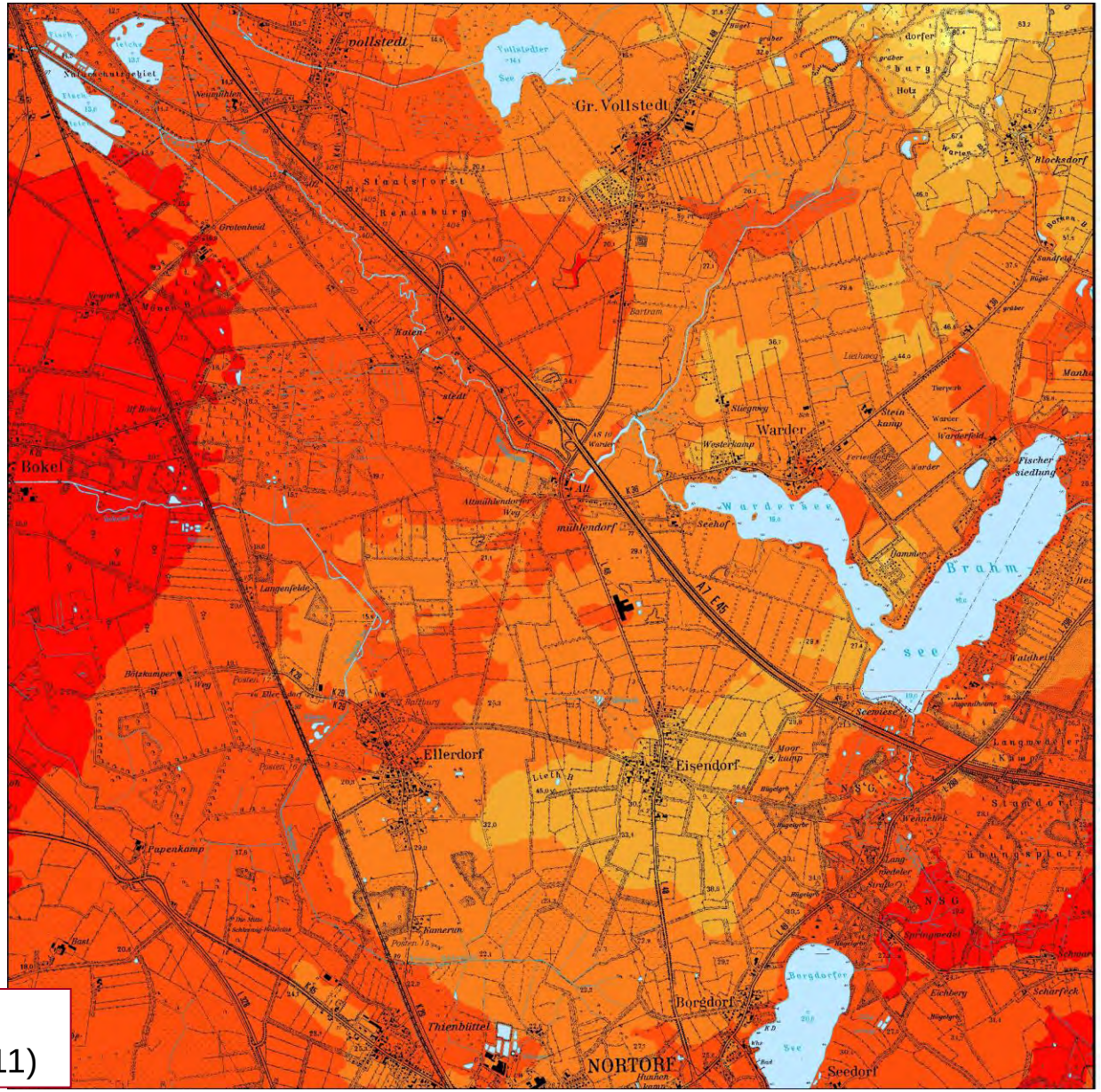
combining both: effective thermal conductivity



effektive Wärmeleitfähigkeit für Bohrtiefe 100m

- 🟨 1,0
- 🟨 1,2
- 🟧 1,4
- 🟧 1,6
- 🟧 1,8
- 🟥 2,0
- 🟥 2,2

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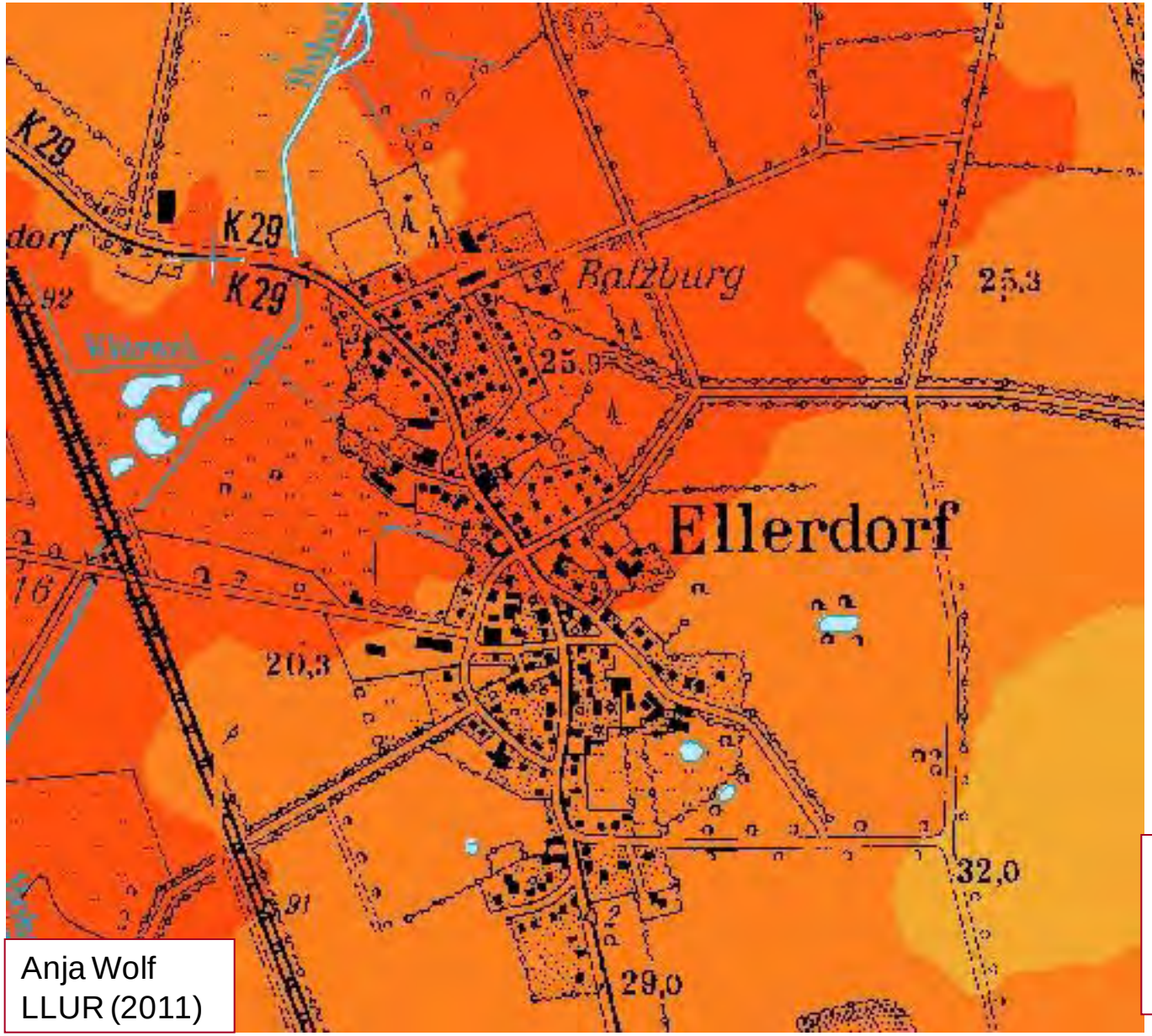

effective thermal conductivity for drillings of 100 m length

- 1,0
- 1,2
- 1,4
- 1,6
- 1,8
- 2,0
- 2,2

in W/mK

→ data base for the design of ground heat exchanger

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LLUR (2011)

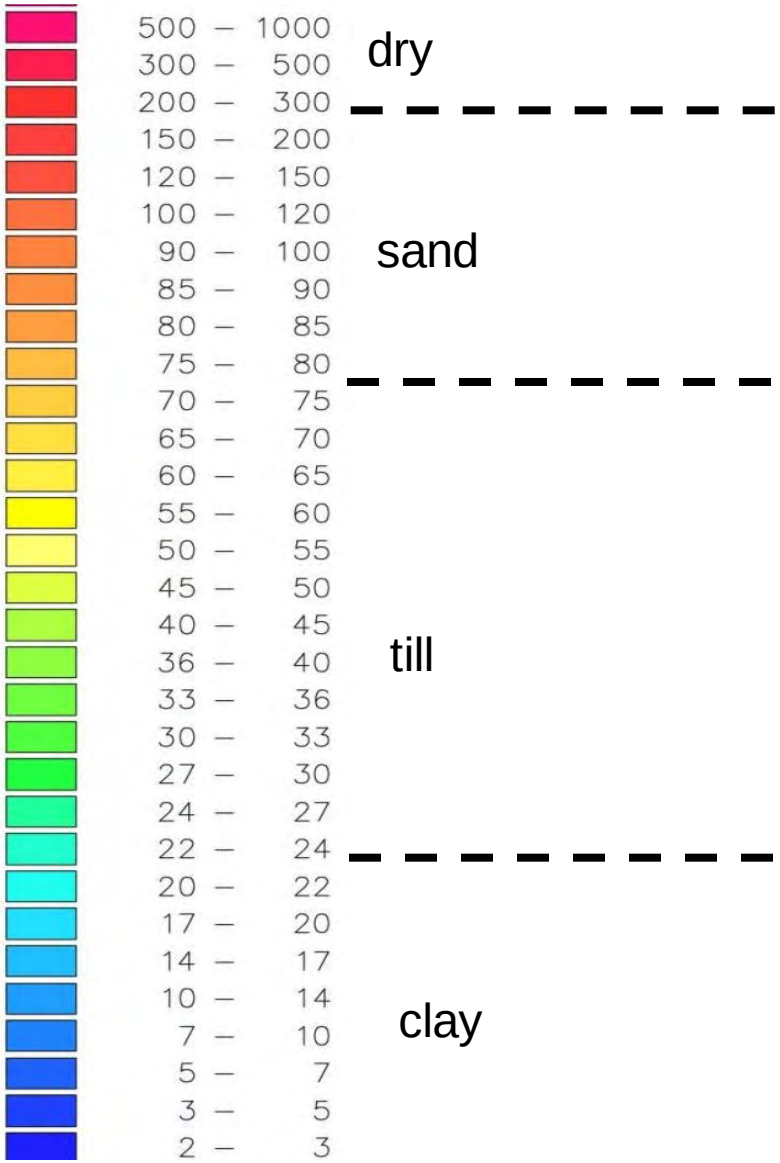
our dream (partly in progress): data bank of regionalized thermal conductivities for sand, till and clay

Border crossing cooperation would be nice!!

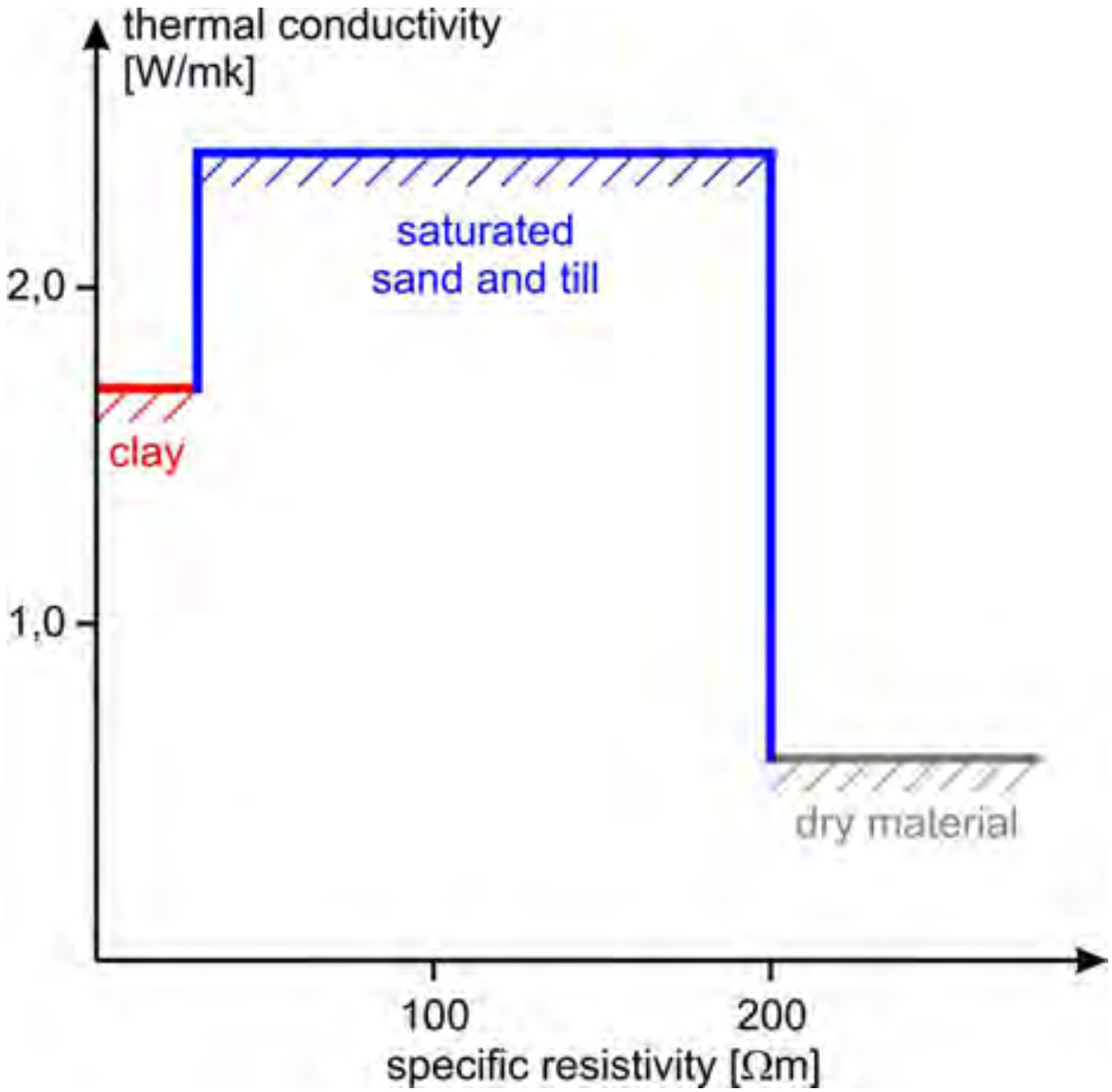
Just an idea:

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

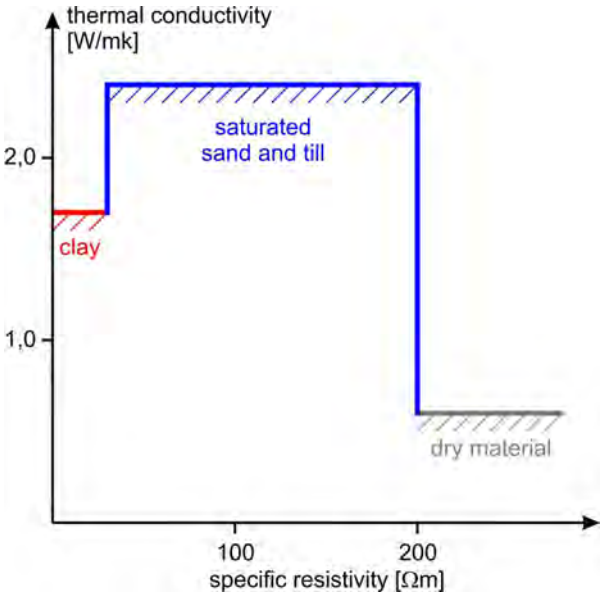
e.g. using electrical resistivities……

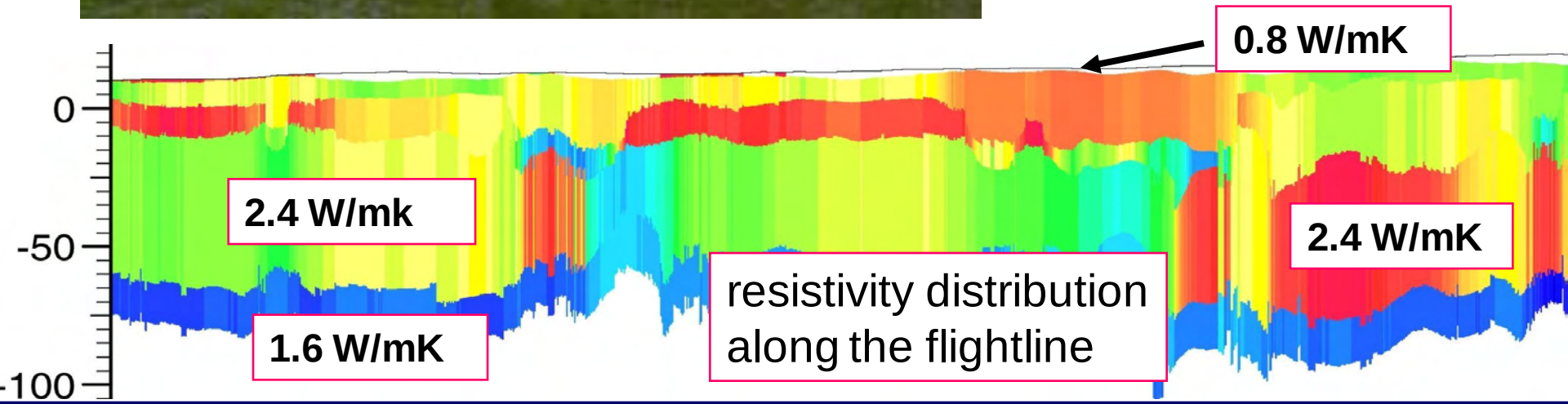


so we can establish a relation of electical resistivity and thermal conductivity



Airborne EM: large scale resistivity mapping





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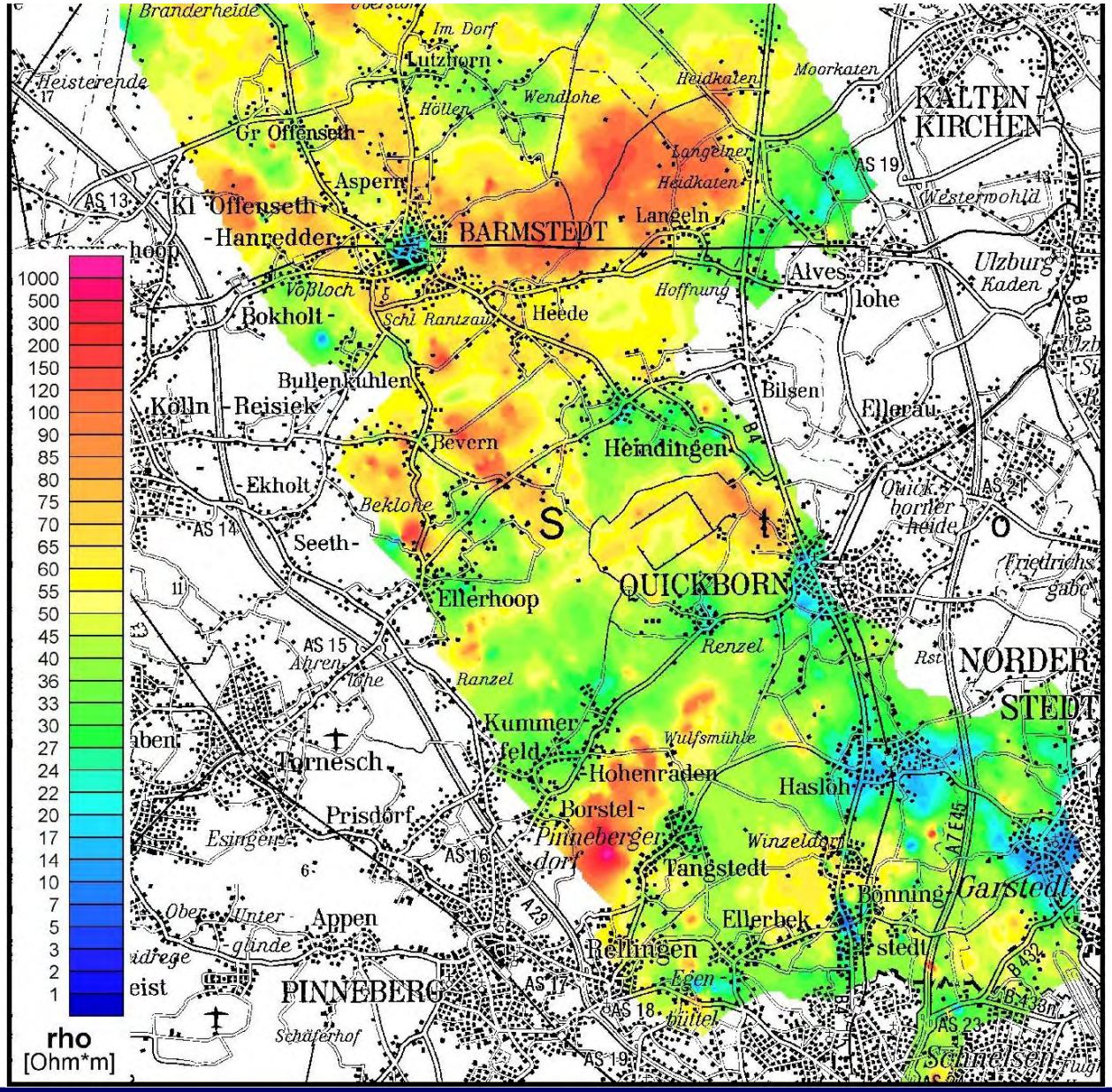
- Geologischer Landesdienst -

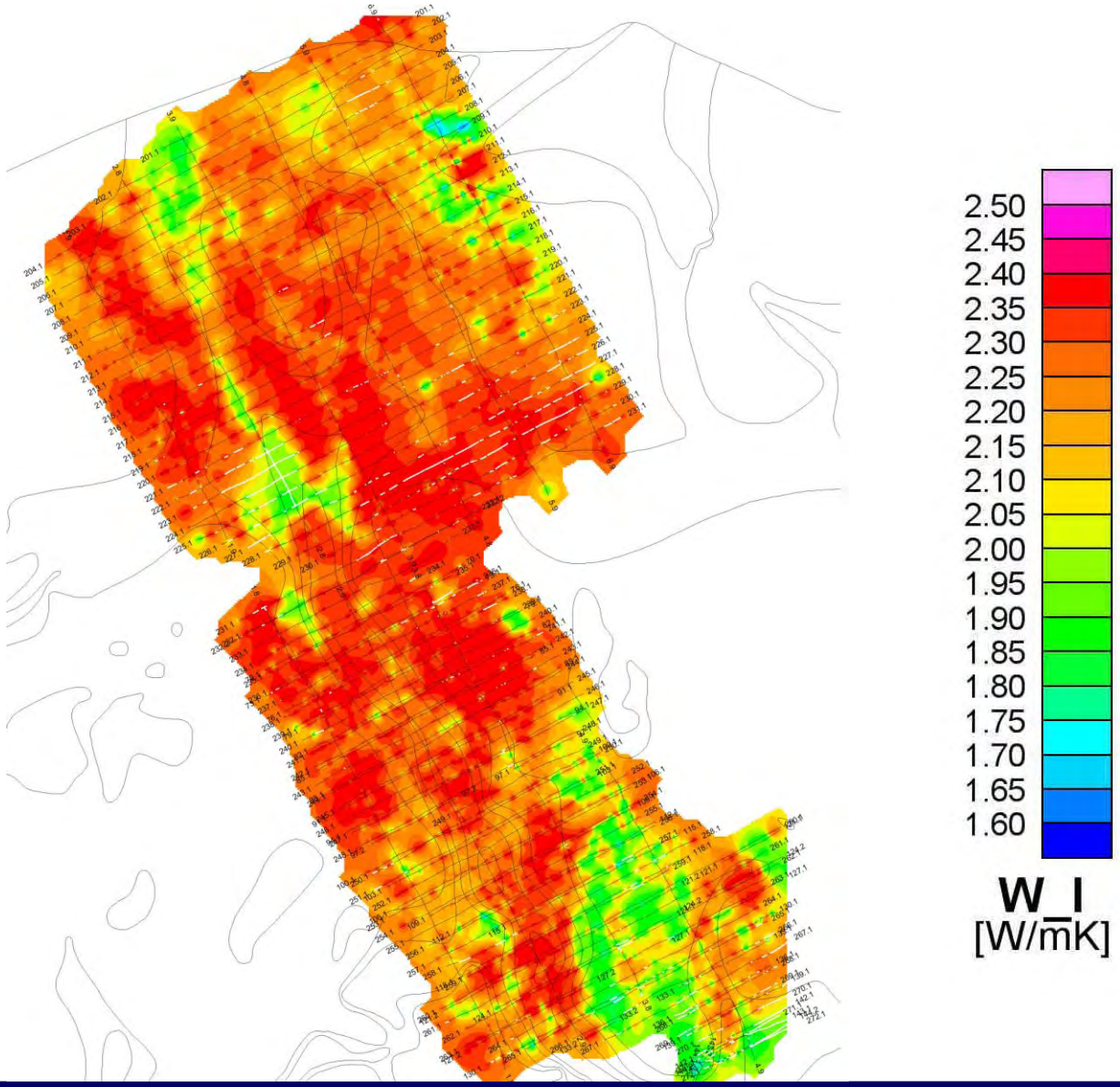
Interreg project BURVAL: mapping of buried valleys

Results of BGR-HEM survey: resistivity distribution at 0 m bsl

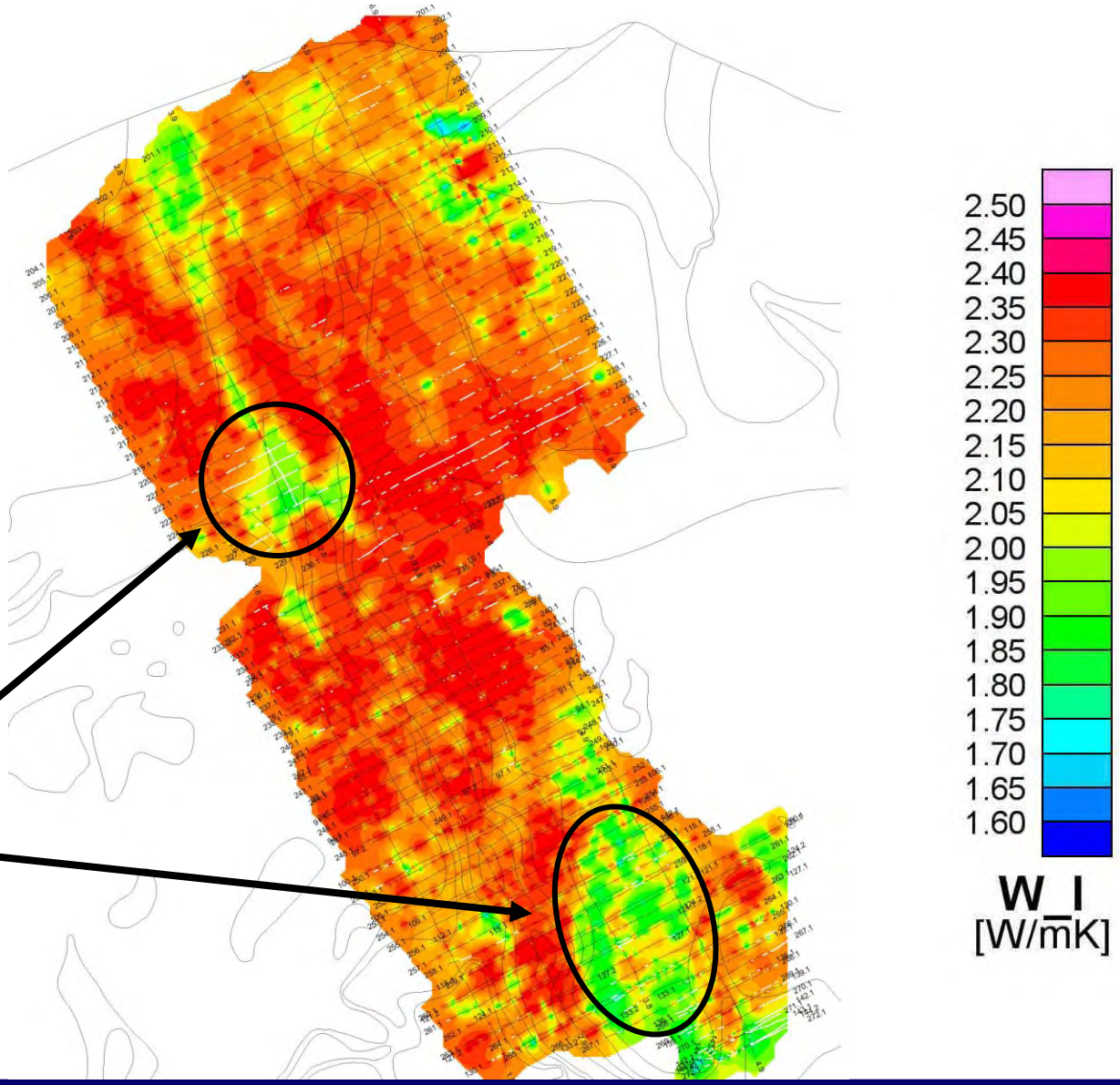


average thermal conductivities down to 70 m,

calculated from airborne EM resistivity distribution



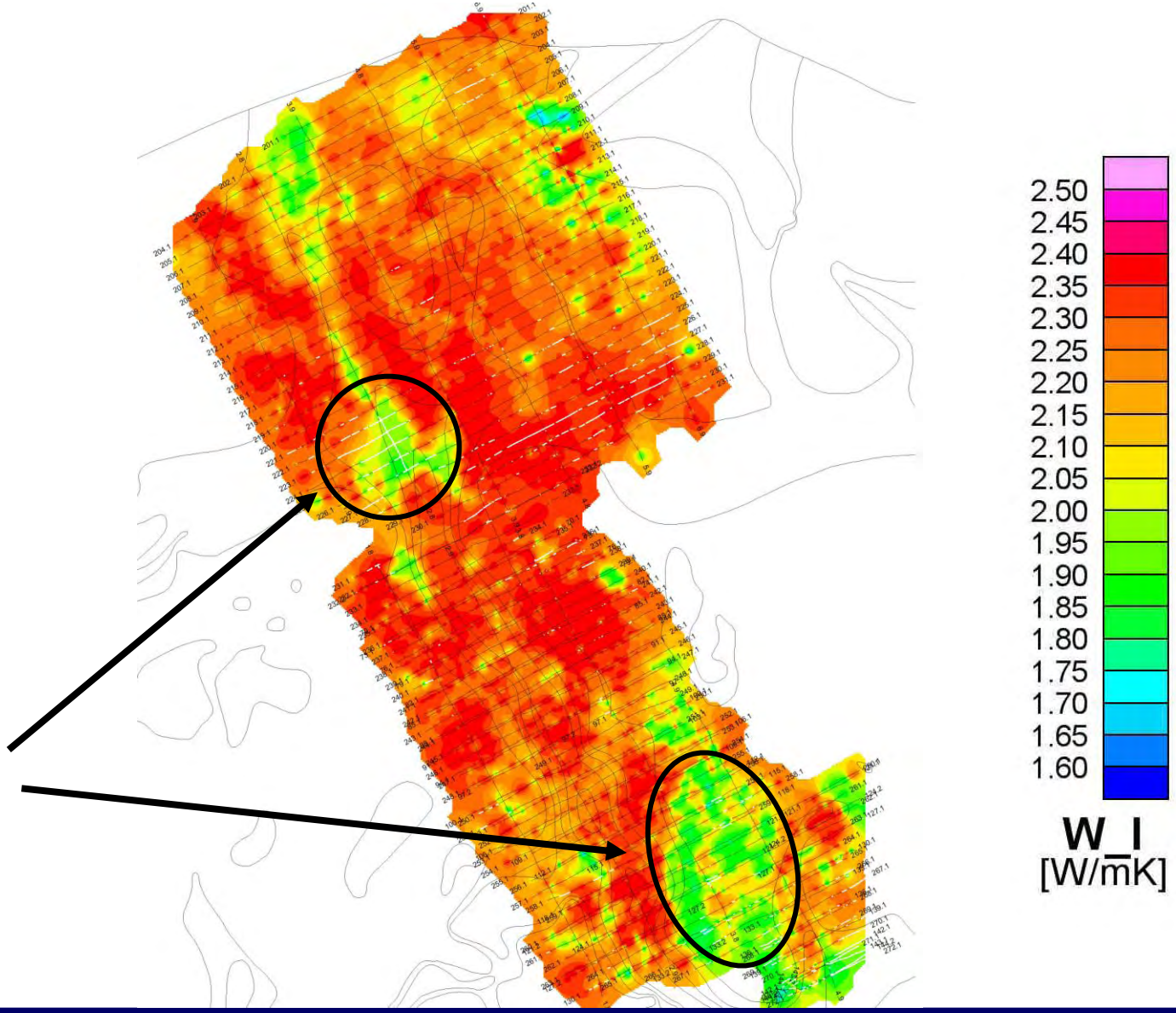
average thermal conductivities down to 70 m



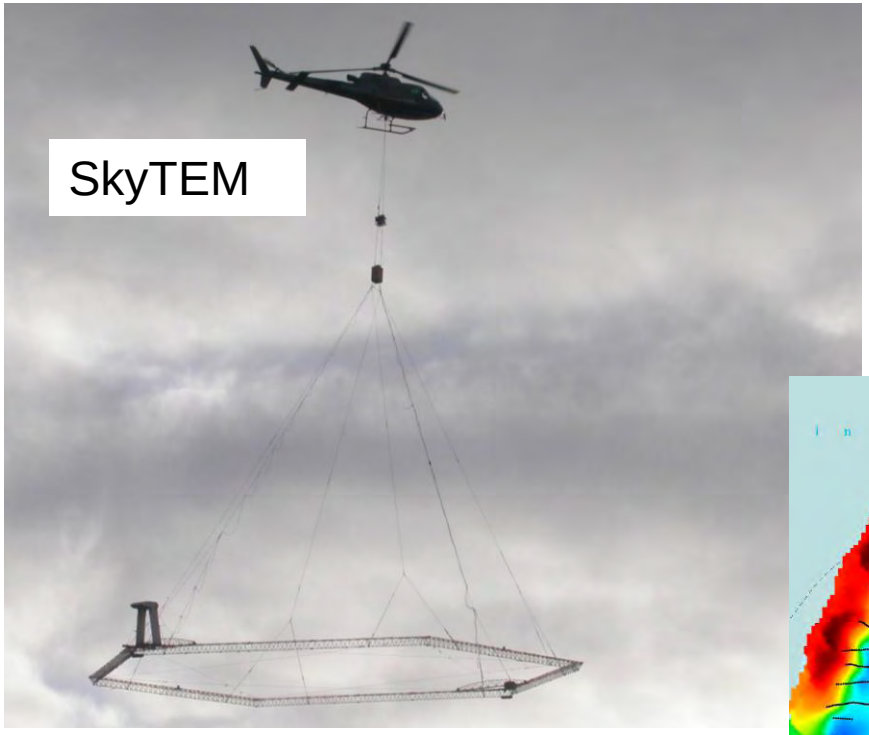
disturbed signals in urban areas

average thermal conductivities down to 70 m

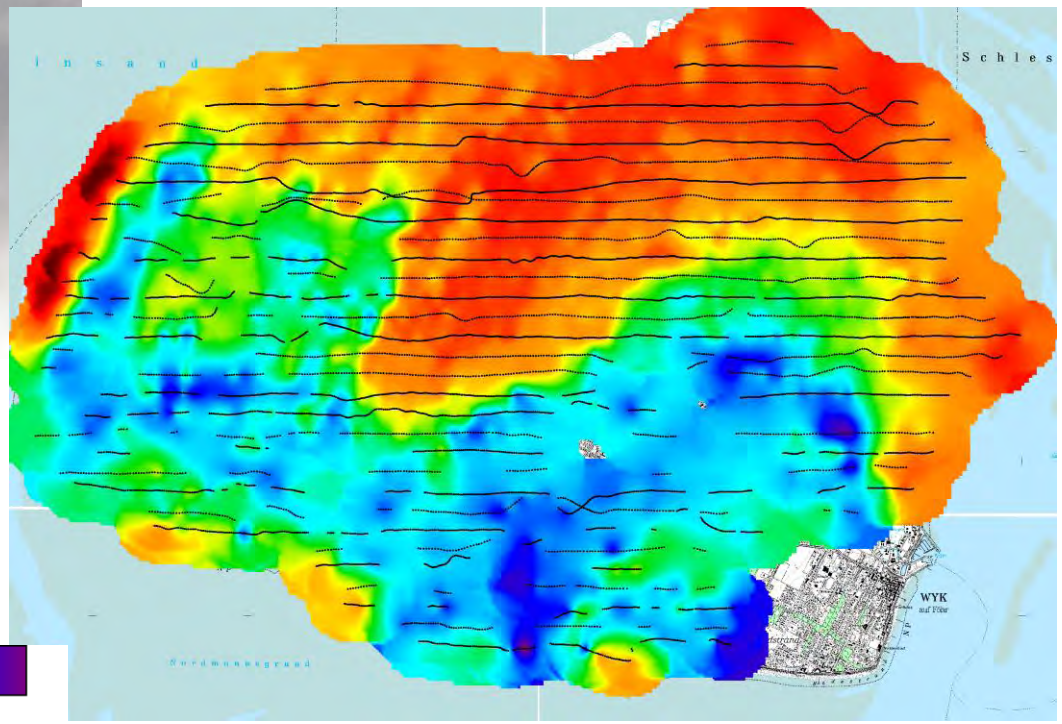
disturbed signals in urban areas – but here we have a higher density of drillings



Large areas of Denmark (and to a minor extent Schleswig-Holstein) are covered with airborne EM resistivity results

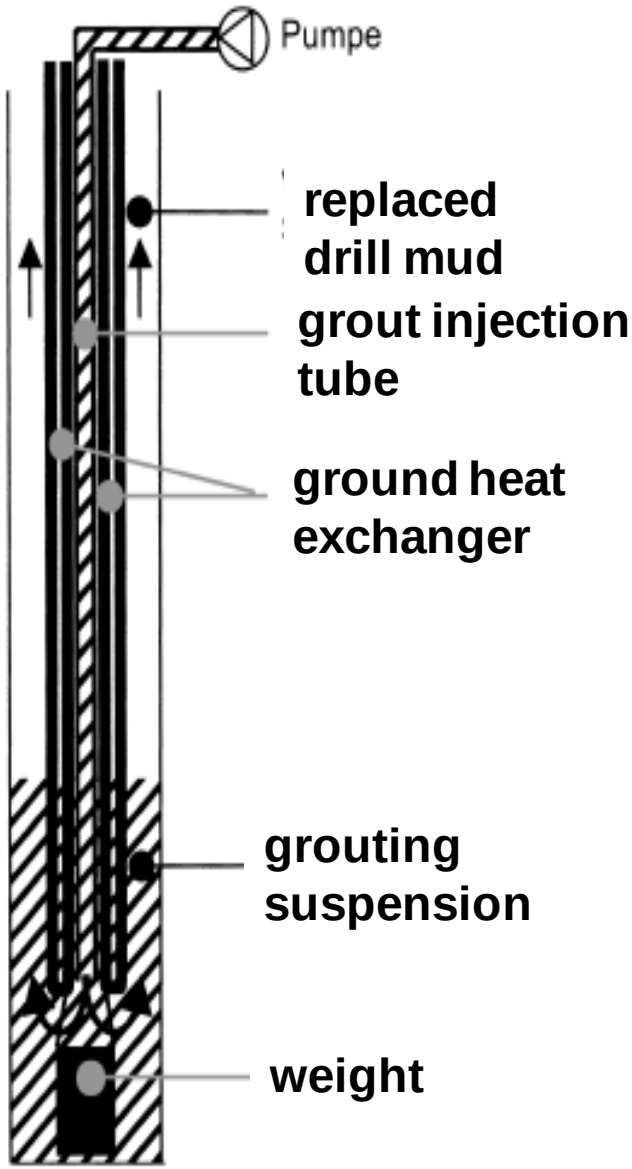


here e.g. the North Sea island of Föhr



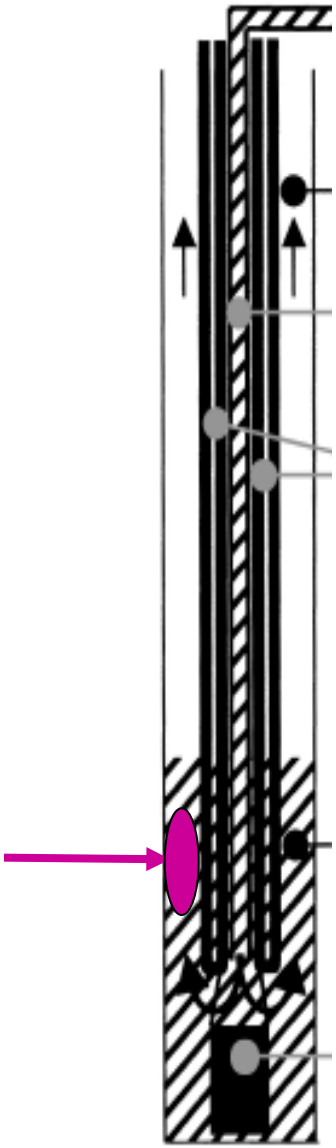
Is this a good database for geothermal mapping?

Grouting control: is the borehole completely filled with cement??



cavities left?

or has the borehole never been filled with cement?



Cooperation project:

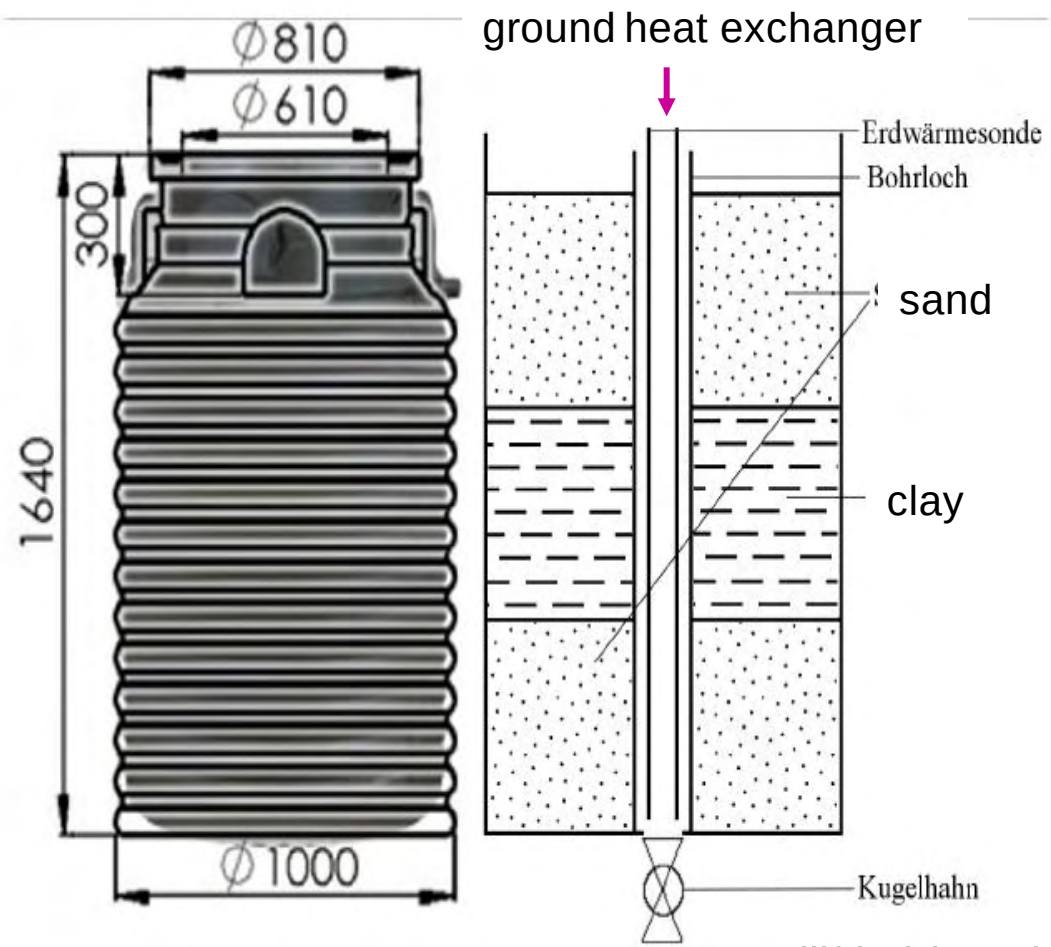
BLM Storkow

TU Berlin

LLUR Flintbek

is a grouting control possible using passive gamma ray techniques?

simulated bore hole

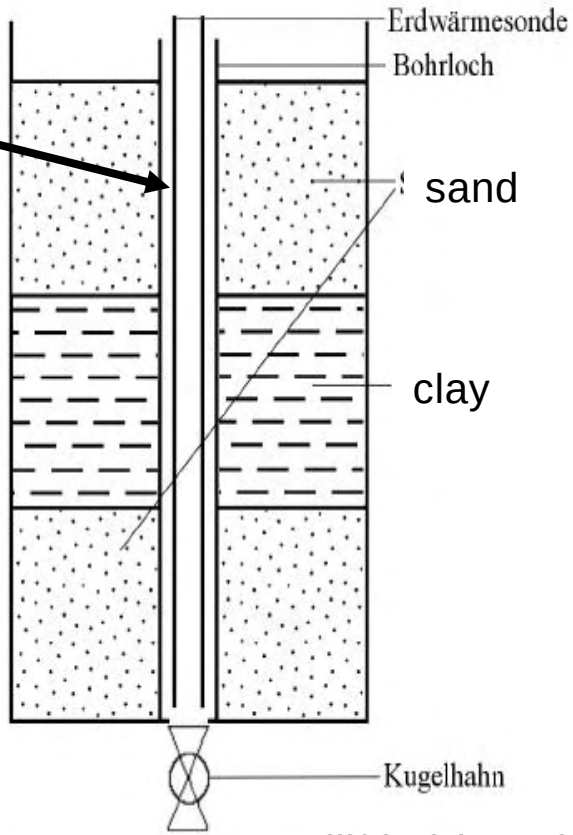


v. Stillfried (2010)

simulated bore hole

filled with different grouting material

ground heat exchanger

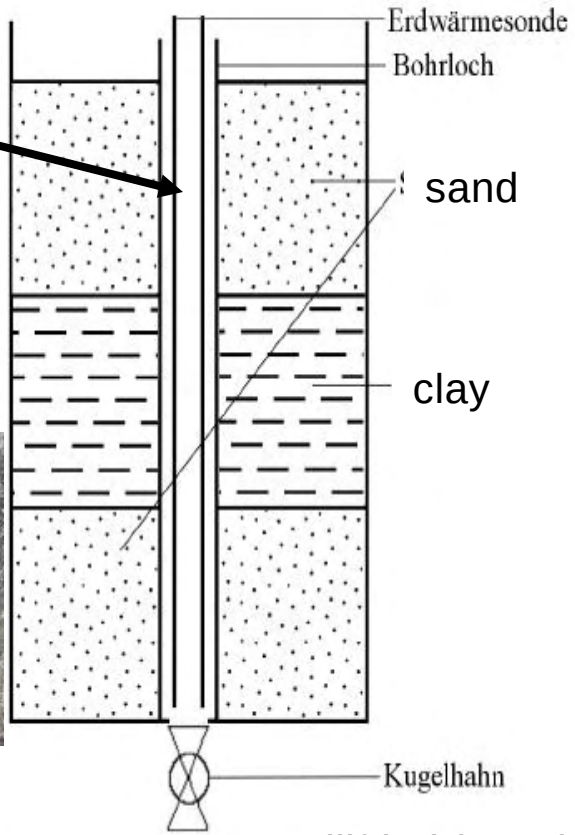


v. Stillfried (2010)

simulated bore hole

measuring the gamma ray activity inside the ground heat exchanger tube

ground heat exchanger



special borehole equipment developed by BLM

v. Stillfried (2010)

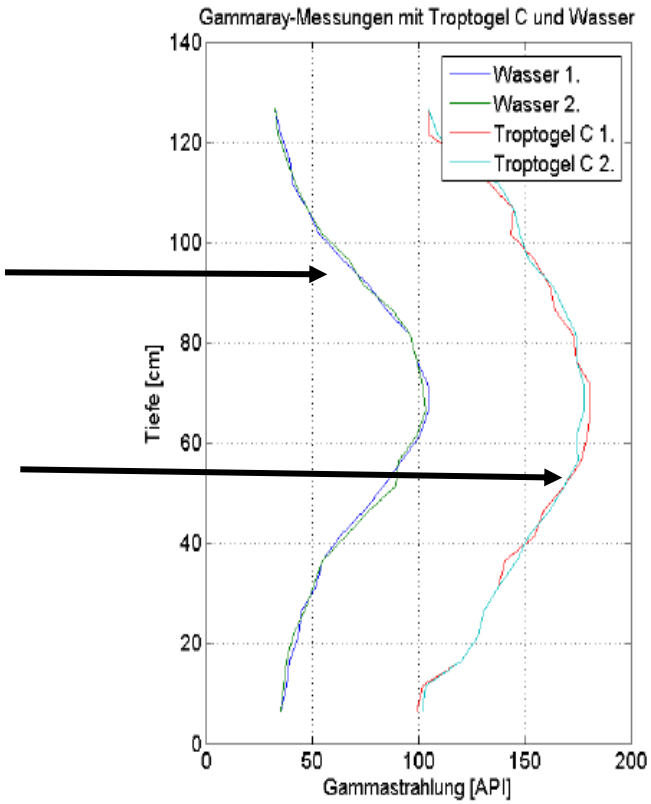
background gamma-effect of the simulated claylayer

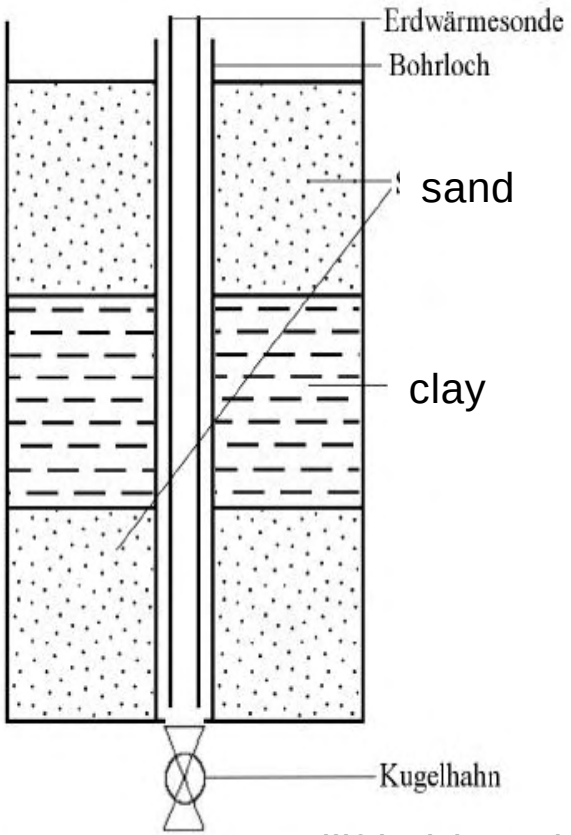
simulated bore hole

ground heat exchanger

water instead of cement

cement with circonium sand added (slightly gamma active)

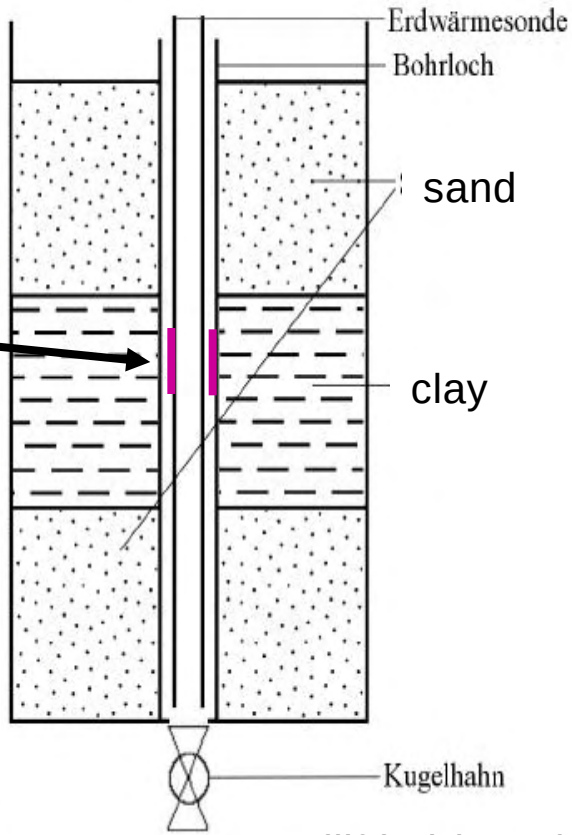




v. Stillfried (2010)

simulated incomplete filling

ground heat exchanger

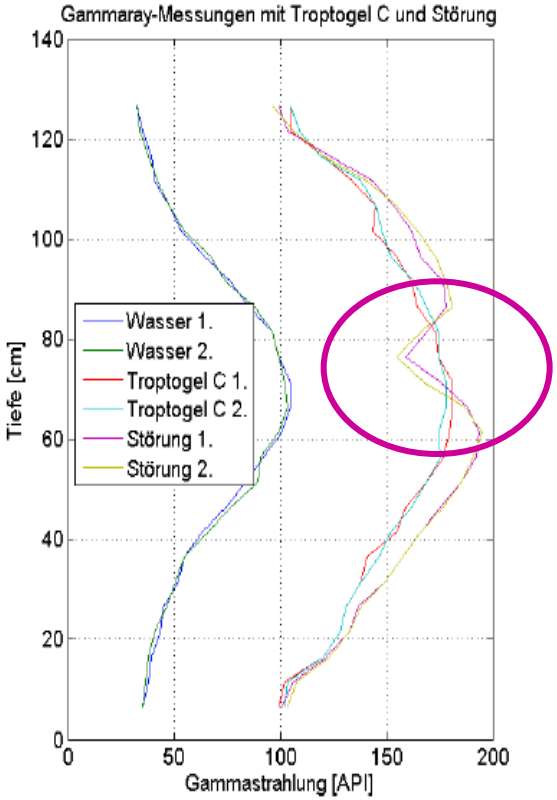


v. Stillfried (2010)

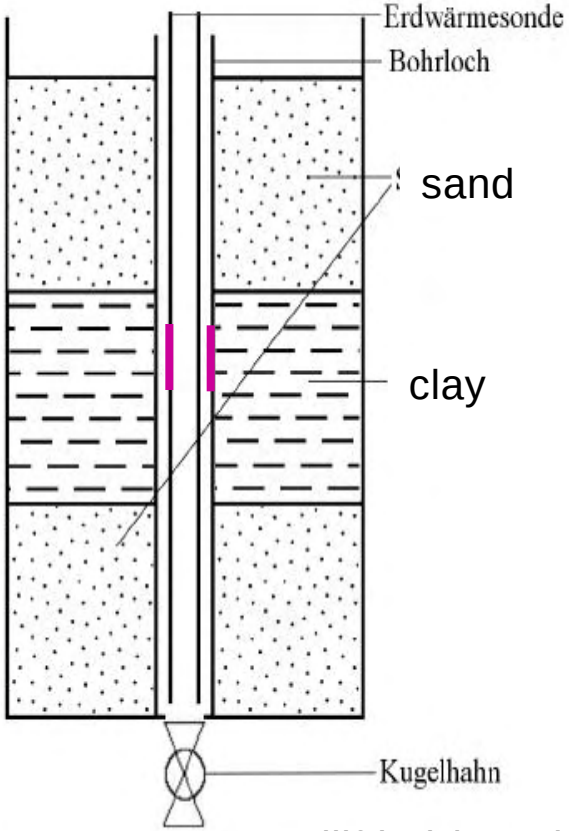
simulated bore hole

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

but: the cement must be slightly radioactive



ground heat exchanger



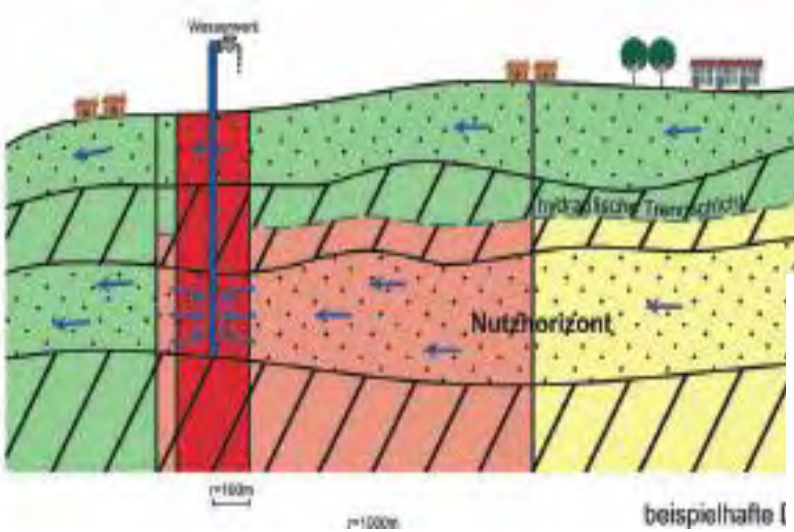
v. Stillfried (2010)

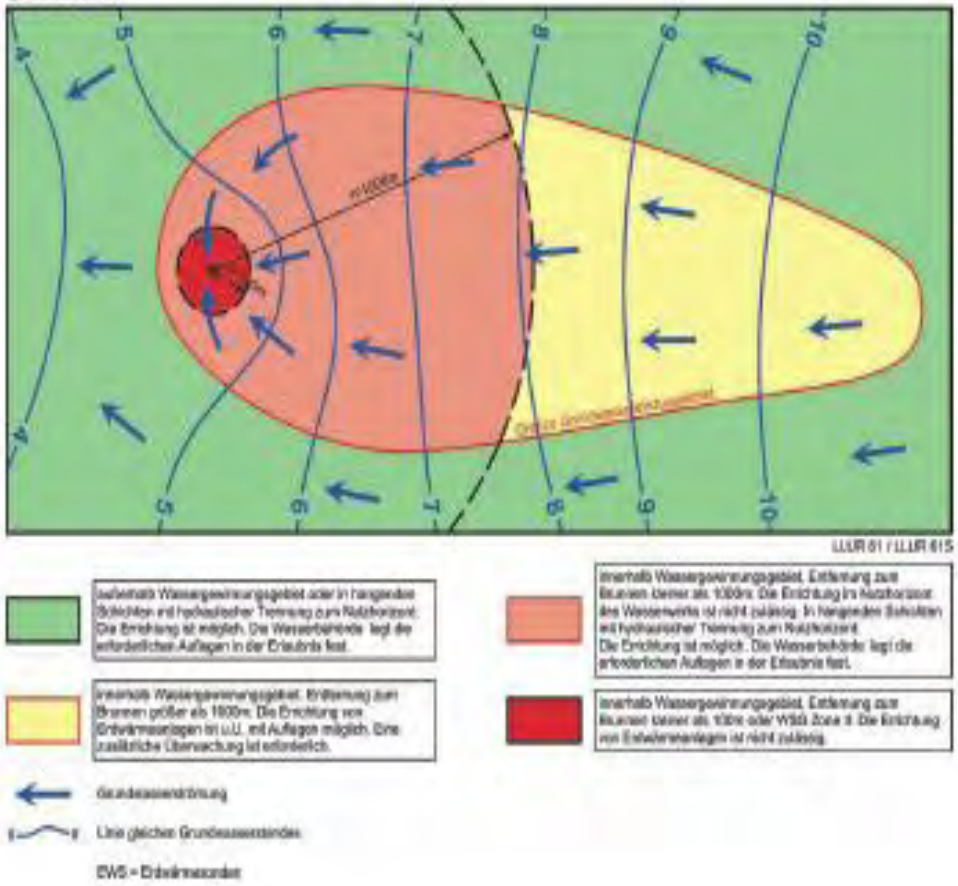
That works fine in the backyard of the BLM company. The next step – when the mini gamma equipment is operable: field tests under different geological conditions in Schleswig-Holstein.

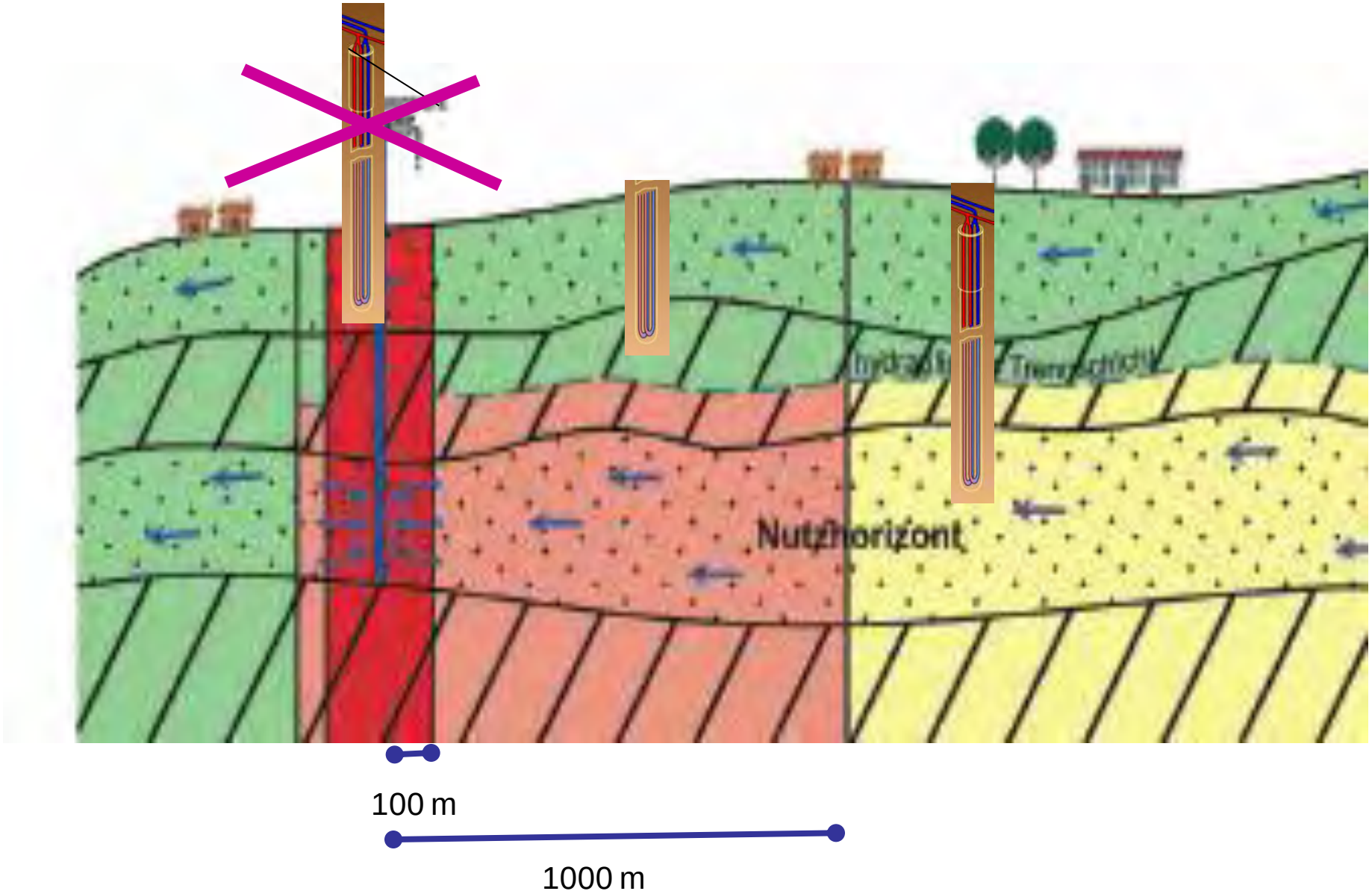
Landesamt für Landwirtschaft, Umwelt und ländliche Räume Schleswig-Holstein

brandnew:

Guidelines for near surface geothermal energy use in Schleswig-Holstein


Wasserwerk
hydraulische Trennschicht
Nutzhorizont
r=100m
r=1000m
beispielhafte


r=100m
LLUR 61 / LLUR 615
Grundwasserströmung
Linie gleicher Grundwasserstandes
EWS = Entnahmeanlage


Nutzhorizont
100 m
1000 m