From resistivity to clay thickness – the SSV concept

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SSV - GeoStatistical Estimation of Structural Vulnerability

The SSV concept

- **Boreholes**
  - Primary information (clay thickness)
  - Poor coverage in relation to desired information
  - Inconsistent quality (old/new, drill method etc.)

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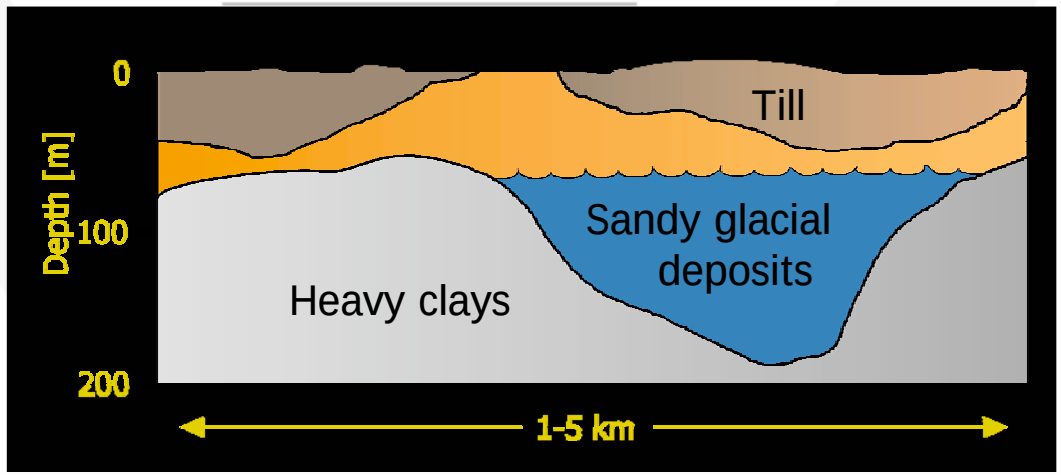
  - Better coverage
  - Consistent known quality



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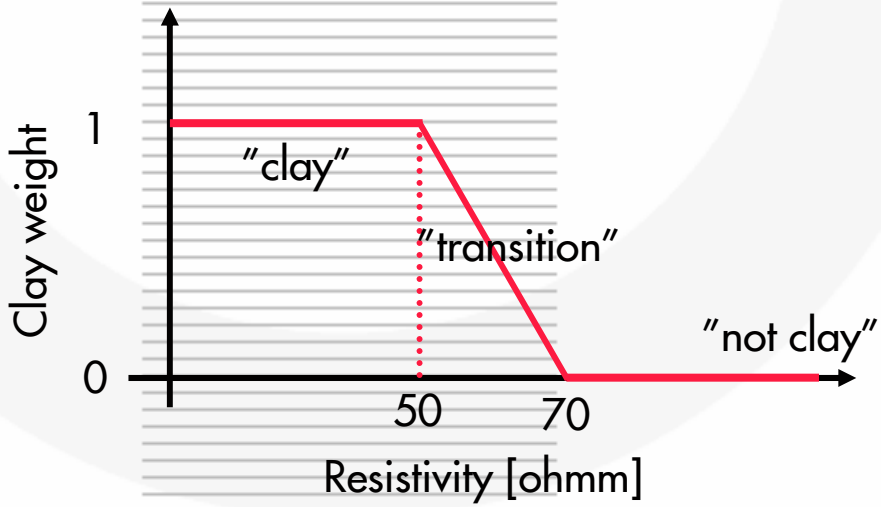

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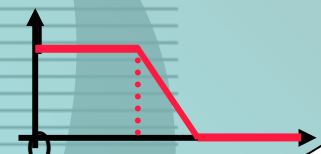
How do we optimally combine this information?

Inversion - SSV !

SSV - players

Translator model, geoph. to clay thickness



Geophysics – layered models

Boreholes, clay thicknesses

Consistency?

SSV - players

Translator model, geoph. to clay thickness

+ uncertainties

Geophysics – layered models

+ uncertainties

Boreholes, clay thicknesses

+ uncertainties

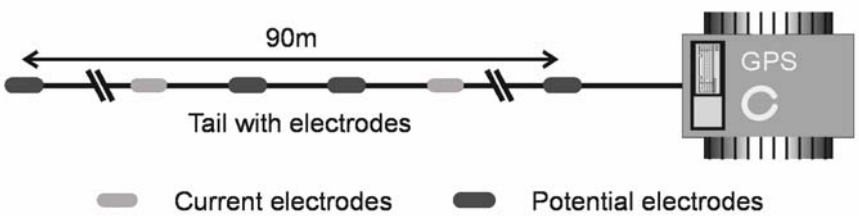
Consistency?

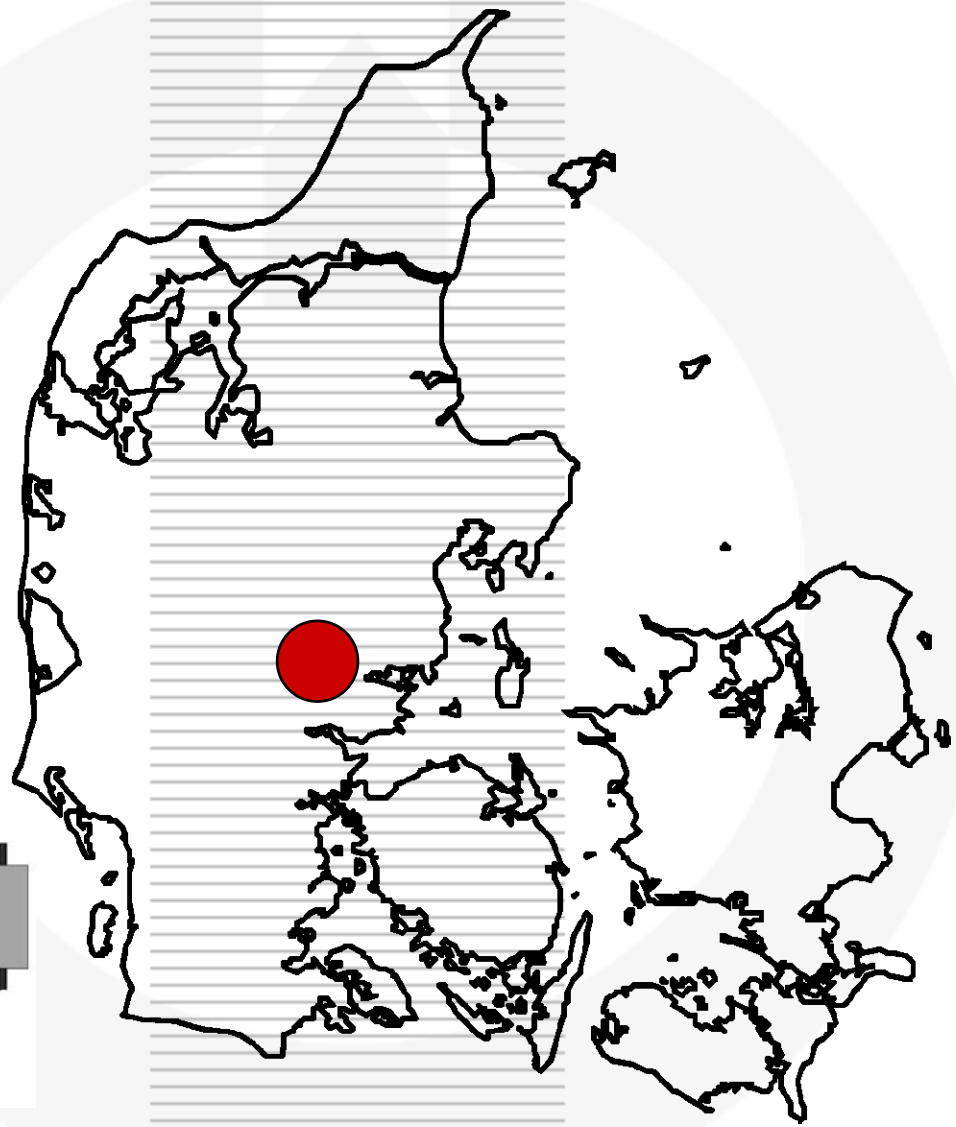
SSV - what is it?

- **SSV is a statistically based inversion algorithm for estimation of geophysical clay thickness**
- **SSV gives the (statistically) best geophysics-to-clay-thickness translator model**
- **$\Rightarrow$ best clay thickness map integrating borehole information and geophysics**

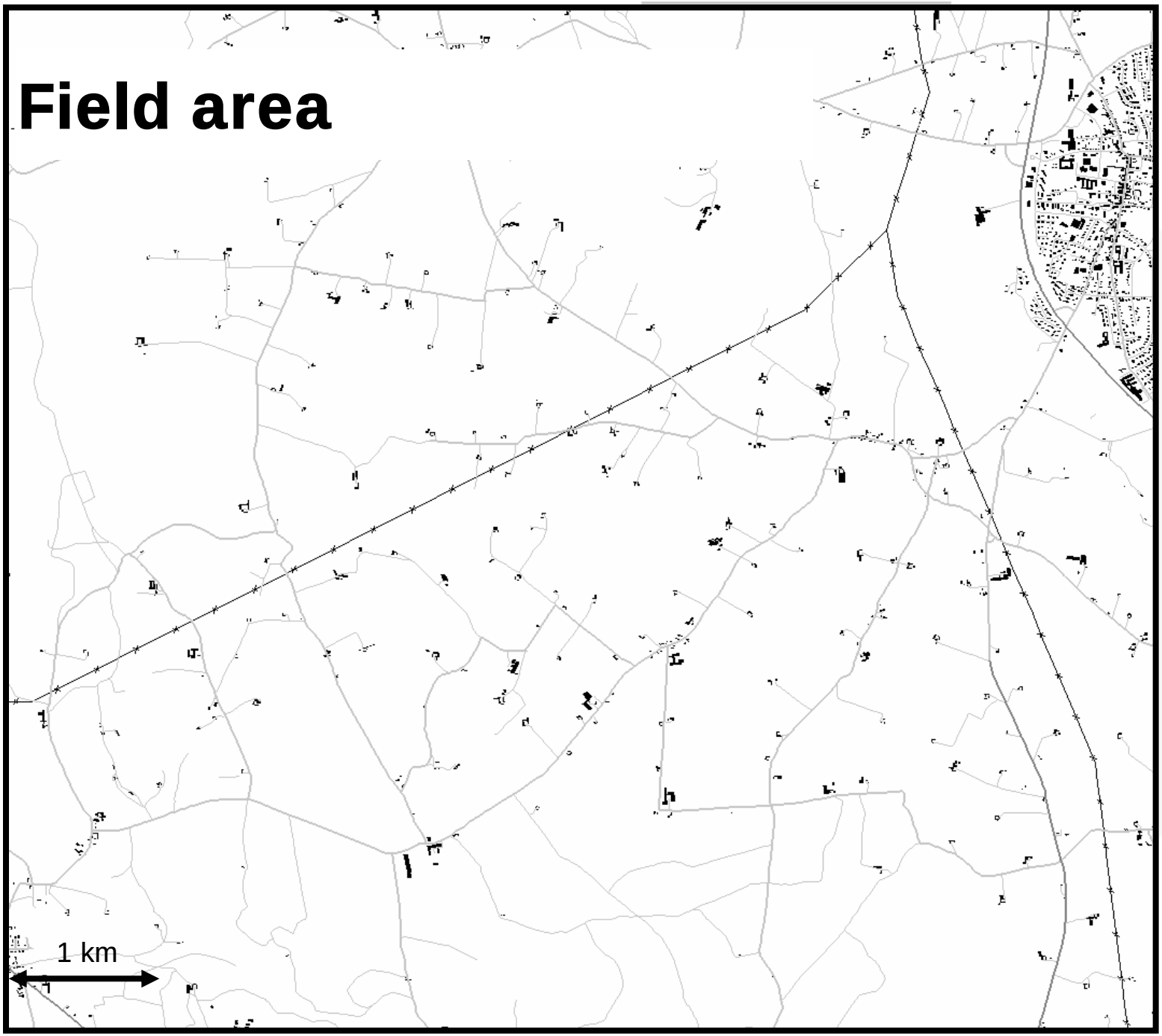
Field example

- 25 km²
- 85 line km of PACES
- → 17,000 1D models
- 64 drill holes (>20 m depth)

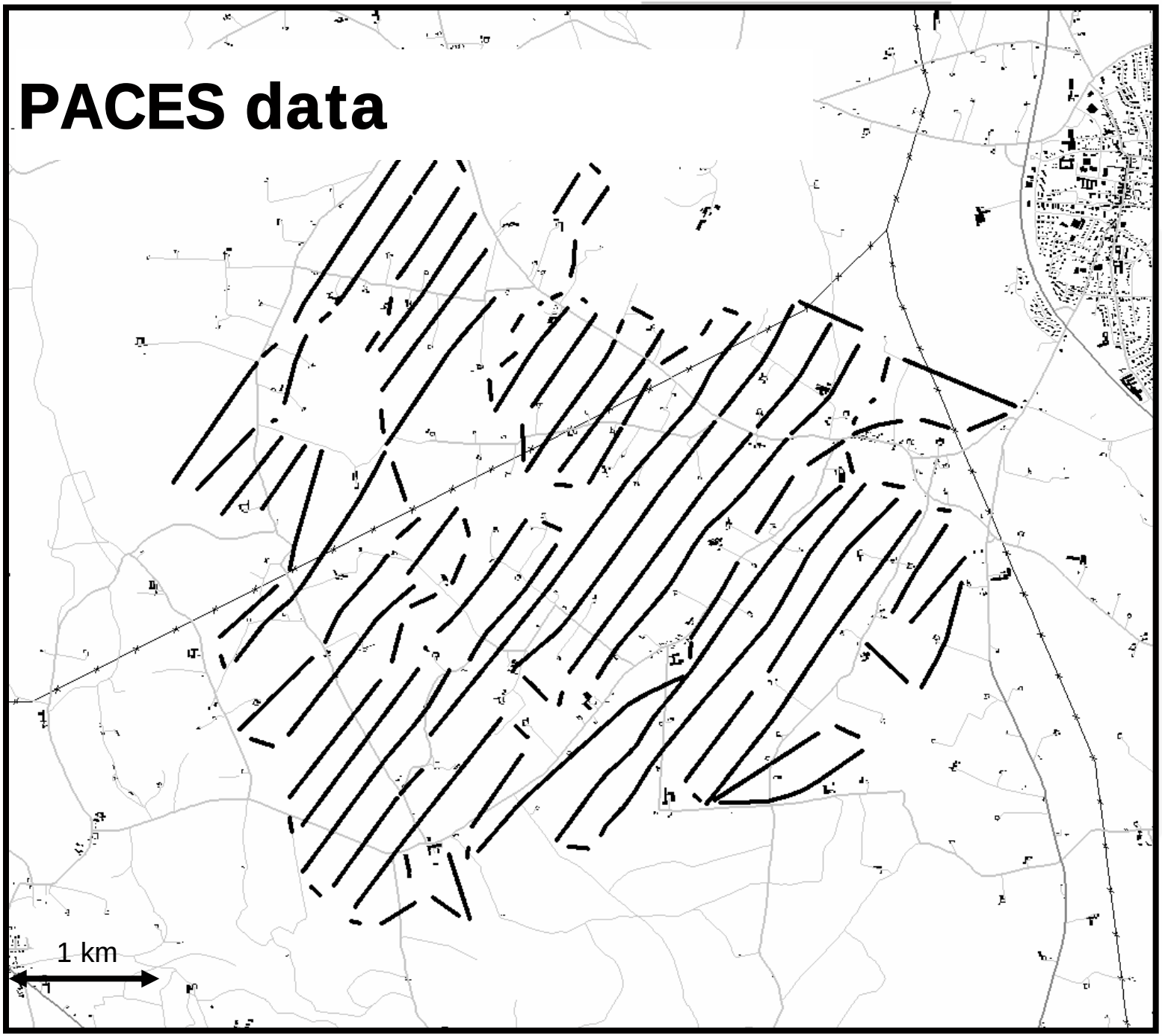




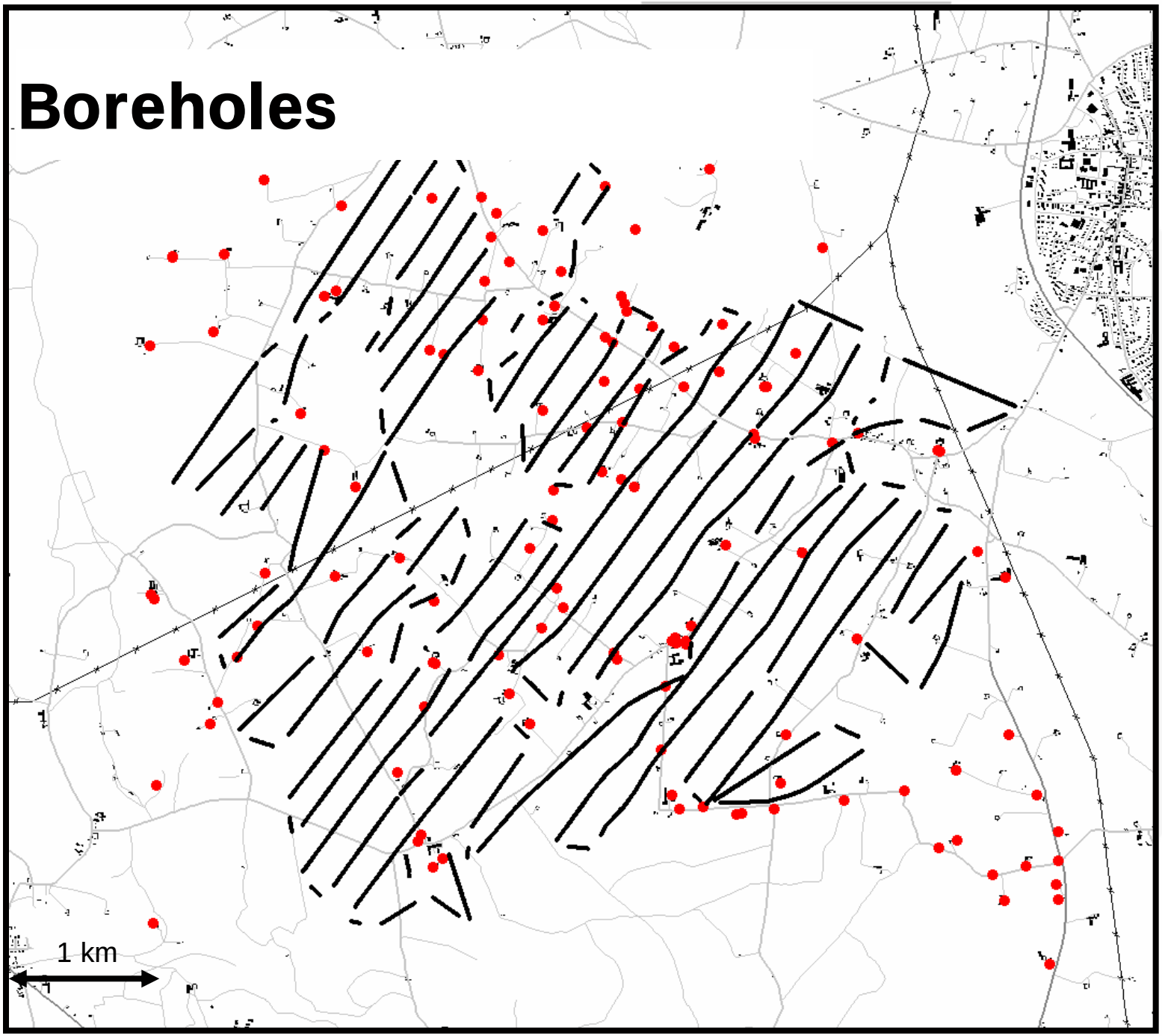
Field area



PACES data



Boreholes



Borehole descriptions

Danmarks og Grønlands Geologiske Undersøgelse — Udskrevet 2/9 2005 Side 1

BORERAPPORT — **DGU arkivnr : 97. 663**

Borested : Fuglrisvej 34
8740 Brædstrup

Kommune : Brædstrup
Amt : Vejle

Boringsdato : 1/9 1981 — **Boringsdybde** : 44 meter — **Terrænkote** : 0 meter o. DNN

Brøndborer : I. Knudsen, Laurbjerg
MOB-nr :
BB-journr :
BB-bornr :

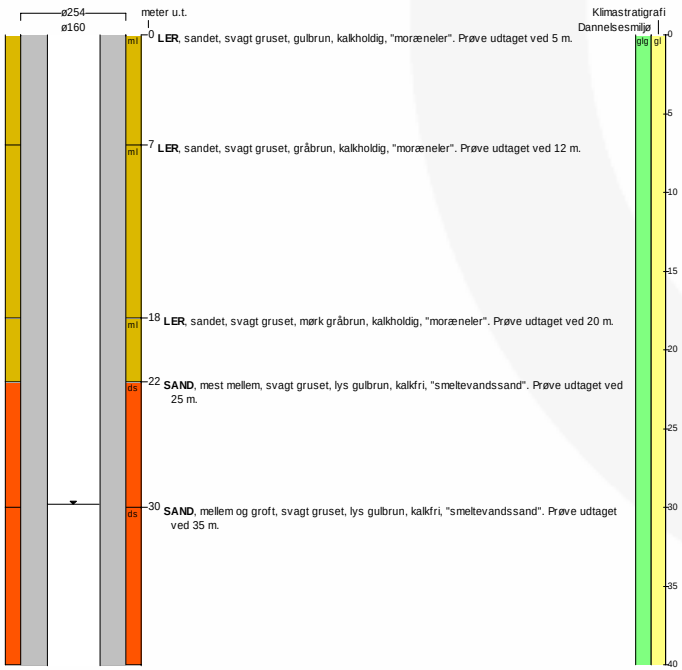
Prøver
- modtaget : 9/9 1982 **antal** : 6
- beskrevet : 11/1 1993
- antal gemt :

Formål : Vandforsyningsboring
Anvendelse :
Boremetode : Tørboring/slagboring

Kortblad : 1214 IINV
UTM-zone : 32
UTM-koord. : 532436, 6202582

Datum :
Koordinatkilde :
Koordinatmetode :

	Ro-vandstand	Pejledato	Ydelse	Sænkning	Pumpetid
Indtag 1 (seneste)	29.8 meter u.t.	1/9 1981	4 m³/t	1.6 meter	1.5 time(r)



fortsættes..

906877 Meddelelse om boring

Borerapport fra

Laurbjerg Brøndboring
I. KNUDSEN
8765 KLØVBORG TLF. 05-76 11 05

dato 2 - 9 - 1981

denne side sendes til

Danmarks Geologiske Undersøgelse (DGU) (22)
Thoravej 31 - 2400 København NV
Telefon: (01) 10 66 00

6 Pr.

INDFØRT

Boringen udført for	navn: Bjarne Tolstrup		tlf. nr.: 05-760072
	adresse: Fuglrisvej 34	by: Brædstrup	post nr.: 8740
Borested	adresse/ejendomsnavn: Fuglrisvej 34		kommune: Brædstrup
			amt: Vejle
Udført i tiden	fra dato / år: 26-8-81	til dato / år: 1-9-81	formål: Drikkevand
			boremetode: Stødbor
Borerør	udv. diam. / dybde: 10" til 11 m	udv. diam. / dybde: 8" til 44 m	udv. diam. / dybde: til m
			kortblad nr.: 1214 II NV
Forerør og blindrør	udv. diam. / dybde: 160 fra 0-41, 20 m	materiale: PVC	blindrør til / udv. diam.: m
			afstand til kortkanter i mm: N 206 V 118 Ø S
Filterrør	udv. diam.: 90 mm	materiale: PVC	spaltebredde/maskevidde: 0,7 mm
Filterinterval	fra / til: 41,7-43,7 m u. terr.	fra / til: m u. terr.	gruskastning: 1,5 - 2,2 mm
Pejling	før pumpning (ro-vandstand): 29,80 m u. terr.	før pumpning (ro-vandstand): m o. terr.	før stop af pumpning: 31,40 m u. terr.
Renpumpning eller prøvepumpning	m³ pr. time ved m sænkning: 4 / 1,6	m³ pr. time ved m sænkning: /	m³ pr. time ved m sænkning: /
	pumpet i: 1½ timer	pumpet i: timer	pumpet i: timer
Tilbagepejling	vandstand under eller over terræn ved følgende tidspunkter efter stop af pumpning: 3 min. 29,8 10 min.	30 min.	2 timer 6 timer
			Terrænhøjde: afløst på kort: m; nivelleret: m

Dybder i m u. terræn	Beskrivelse af jordlagenes beskaffenhed, farve, vandføring m. v.	Prøvetagningsdybde m u. terr.	Prøve nr.
0-			
0 - 7	overjord og gul ler	5	5892
7 - 1			5893
18 - 2			5894
22 - 3			5895
30 - 40	klæg sand, vandholdig	35	5896
40 - 44	sand, vandførende	43	5897

Fortsættes på nyt skema

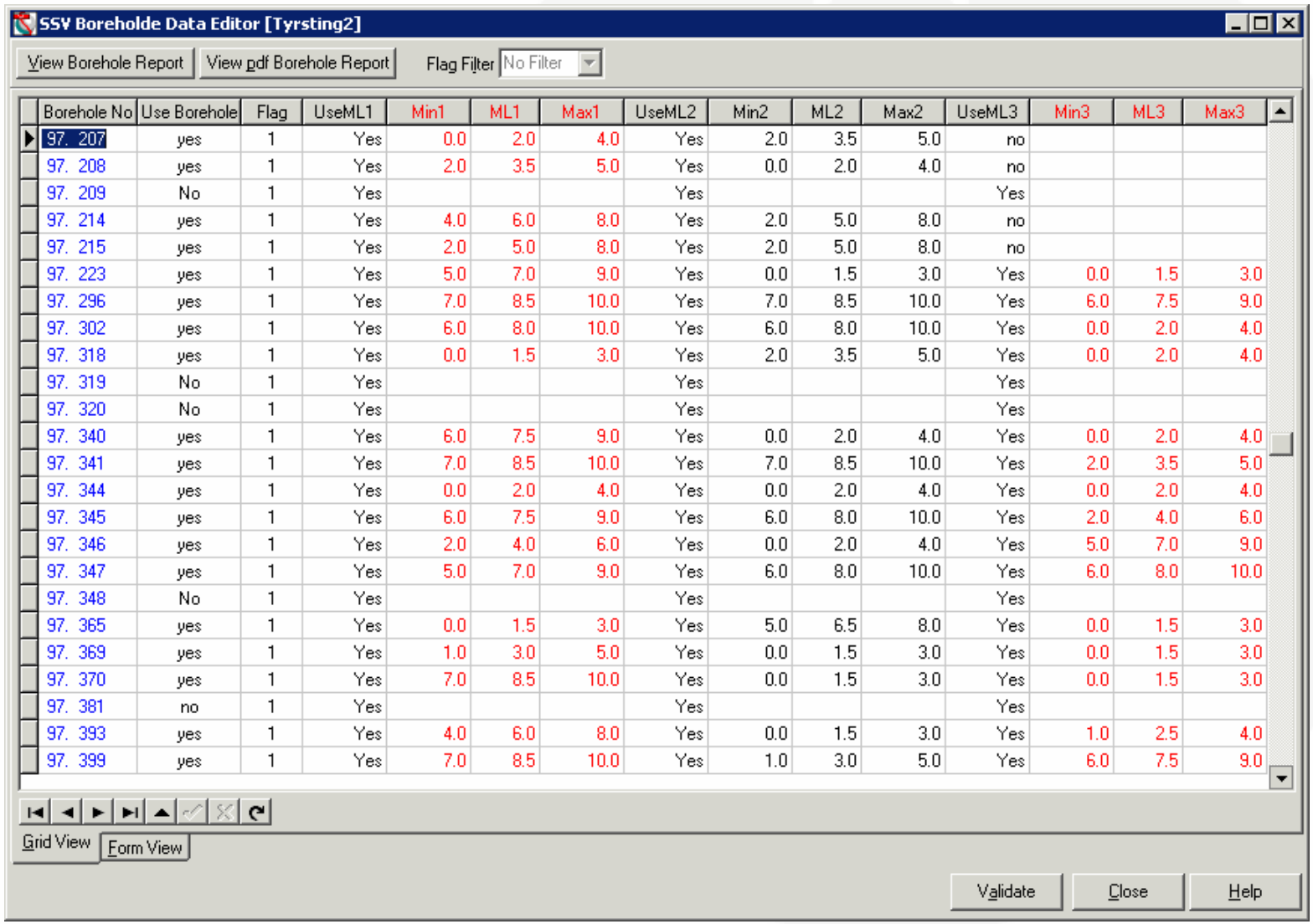
Oa 09-67 ▲

Sandy clay ?

Udfyldes med skrivemaskine eller kuglepen.

Borerapportens første side og jordprøver skal ifbg. vandforsyningsloven indsendes til DGU.
Der udtages **jordprøver** for hver 5 meter, dog mindst to prøver af hvert jordlag.
Eventuel **vandanalyse** bedes vedlagt i kopi eller eftersendt.
DGU's særlige skema til brug ved **prøvepumpning.**
Kopi af DGU's **prøvebeskrivelse** vil blive fremsendt.

Borehole descriptions



Borehole No	Use Borehole	Flag	UseML1	Min1	ML1	Max1	UseML2	Min2	ML2	Max2	UseML3	Min3	ML3	Max3
97. 207	yes	1	Yes	0.0	2.0	4.0	Yes	2.0	3.5	5.0	no			
97. 208	yes	1	Yes	2.0	3.5	5.0	Yes	0.0	2.0	4.0	no			
97. 209	No	1	Yes				Yes				Yes			
97. 214	yes	1	Yes	4.0	6.0	8.0	Yes	2.0	5.0	8.0	no			
97. 215	yes	1	Yes	2.0	5.0	8.0	Yes	2.0	5.0	8.0	no			
97. 223	yes	1	Yes	5.0	7.0	9.0	Yes	0.0	1.5	3.0	Yes	0.0	1.5	3.0
97. 296	yes	1	Yes	7.0	8.5	10.0	Yes	7.0	8.5	10.0	Yes	6.0	7.5	9.0
97. 302	yes	1	Yes	6.0	8.0	10.0	Yes	6.0	8.0	10.0	Yes	0.0	2.0	4.0
97. 318	yes	1	Yes	0.0	1.5	3.0	Yes	2.0	3.5	5.0	Yes	0.0	2.0	4.0
97. 319	No	1	Yes				Yes				Yes			
97. 320	No	1	Yes				Yes				Yes			
97. 340	yes	1	Yes	6.0	7.5	9.0	Yes	0.0	2.0	4.0	Yes	0.0	2.0	4.0
97. 341	yes	1	Yes	7.0	8.5	10.0	Yes	7.0	8.5	10.0	Yes	2.0	3.5	5.0
97. 344	yes	1	Yes	0.0	2.0	4.0	Yes	0.0	2.0	4.0	Yes	0.0	2.0	4.0
97. 345	yes	1	Yes	6.0	7.5	9.0	Yes	6.0	8.0	10.0	Yes	2.0	4.0	6.0
97. 346	yes	1	Yes	2.0	4.0	6.0	Yes	0.0	2.0	4.0	Yes	5.0	7.0	9.0
97. 347	yes	1	Yes	5.0	7.0	9.0	Yes	6.0	8.0	10.0	Yes	6.0	8.0	10.0
97. 348	No	1	Yes				Yes				Yes			
97. 365	yes	1	Yes	0.0	1.5	3.0	Yes	5.0	6.5	8.0	Yes	0.0	1.5	3.0
97. 369	yes	1	Yes	1.0	3.0	5.0	Yes	0.0	1.5	3.0	Yes	0.0	1.5	3.0
97. 370	yes	1	Yes	7.0	8.5	10.0	Yes	0.0	1.5	3.0	Yes	0.0	1.5	3.0
97. 381	no	1	Yes				Yes				Yes			
97. 393	yes	1	Yes	4.0	6.0	8.0	Yes	0.0	1.5	3.0	Yes	1.0	2.5	4.0
97. 399	yes	1	Yes	7.0	8.5	10.0	Yes	1.0	3.0	5.0	Yes	6.0	7.5	9.0

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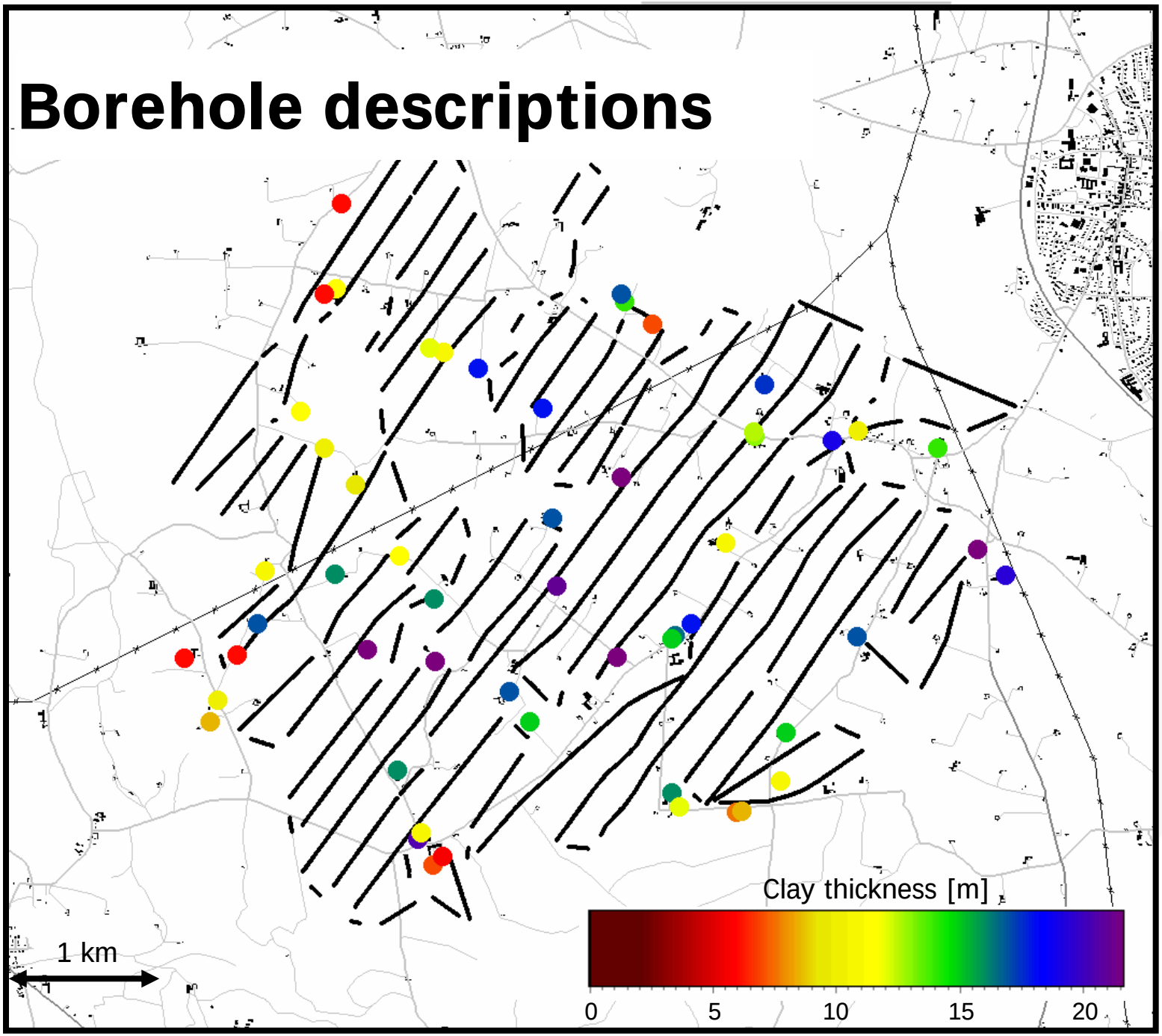
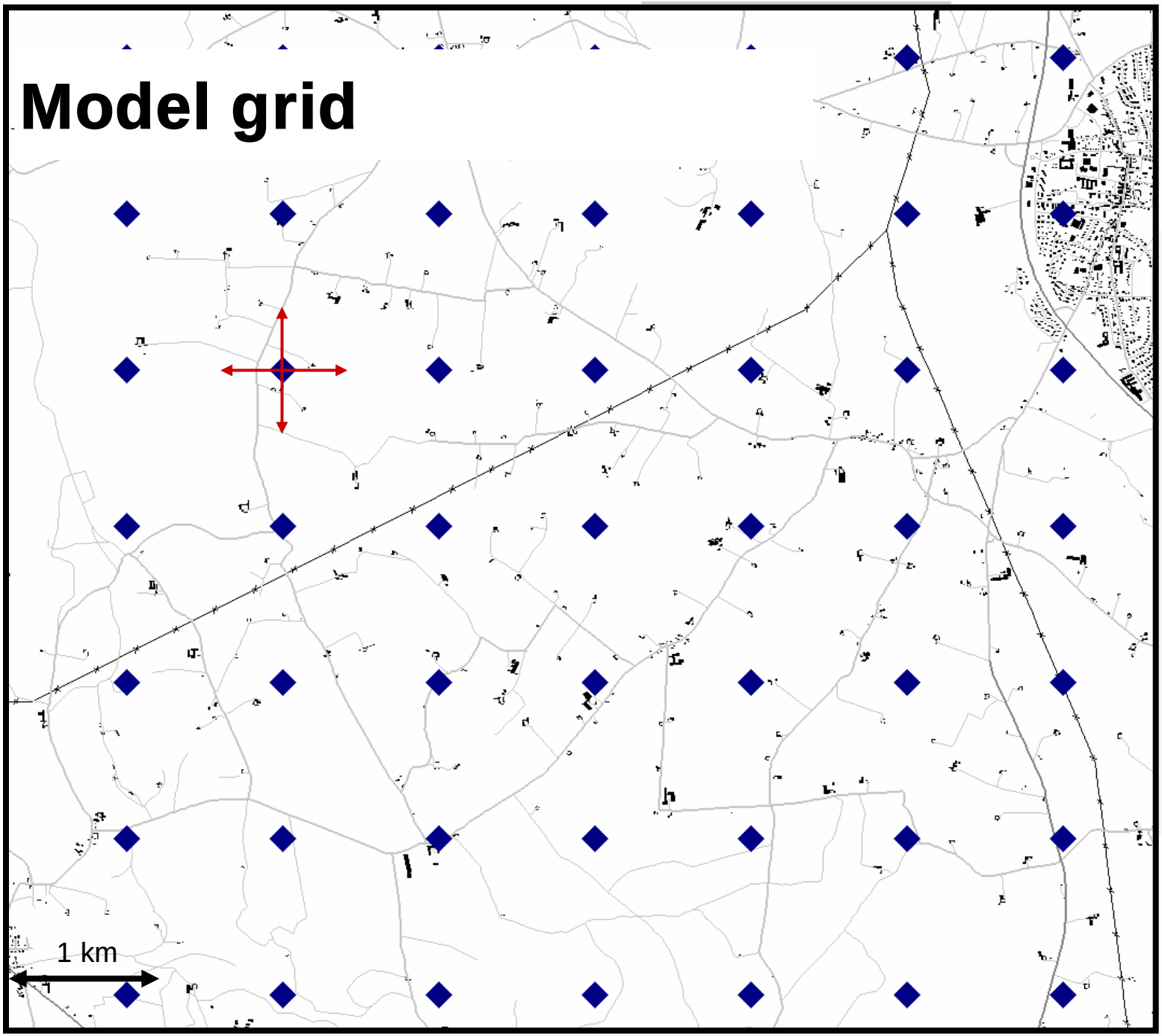
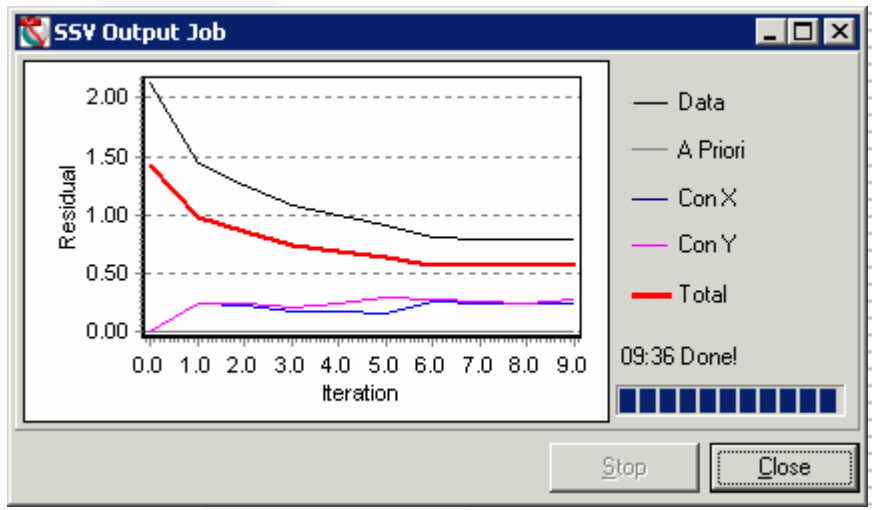


Model grid

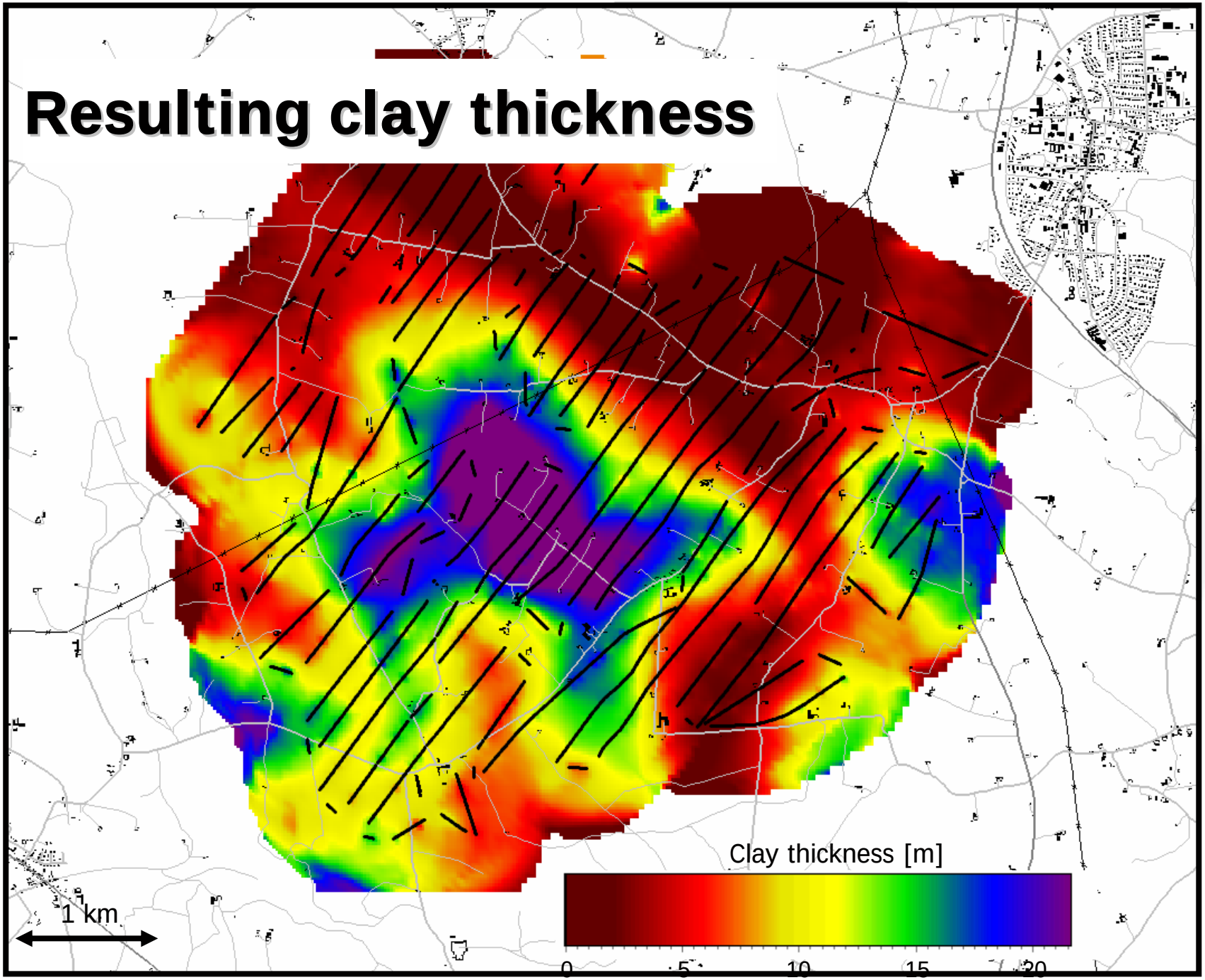


SSV inversion

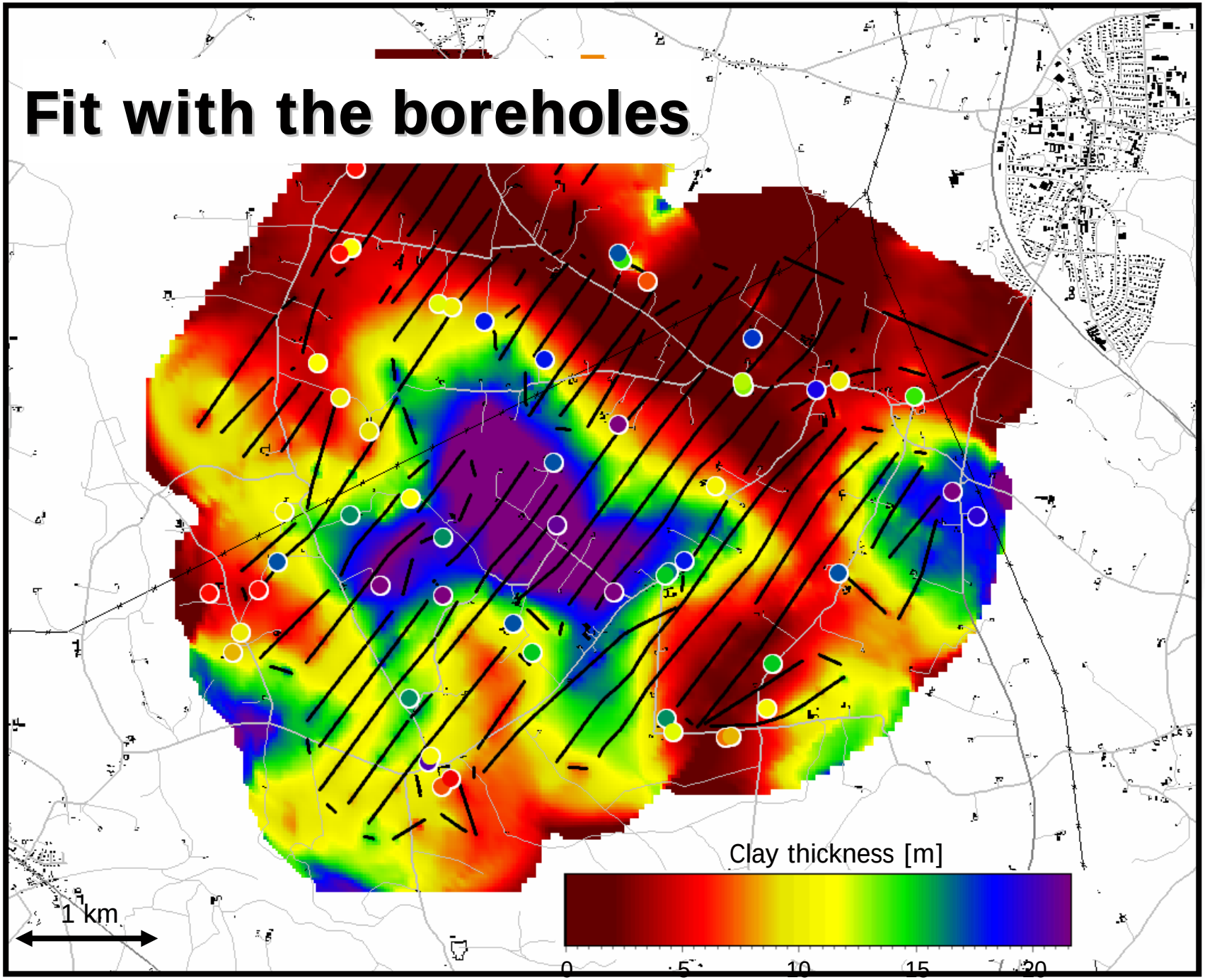
- **Iterative procedure**
- **Least squares solution:** $Q=(d_{obs}-d_{for})^2/\Delta^2$



Resulting clay thickness



Fit with the boreholes



SSV – what can it be used for?

- **SSV provides optimized geophysical clay thickness maps integrating borehole information**
  - Important in the vulnerability mapping
- **SSV incorporates uncertainties of geological information as well as geophysical information and interpolation**
- **SSV provides overview of**
  - Hundreds of boreholes
  - Tens of thousands of geophysical models
- **SSV is operational for large survey areas**

HydroGeophysics Group / SkyTEM booth