GEUS

Udnyttelse af geofysikdata i hydrologisk modellering

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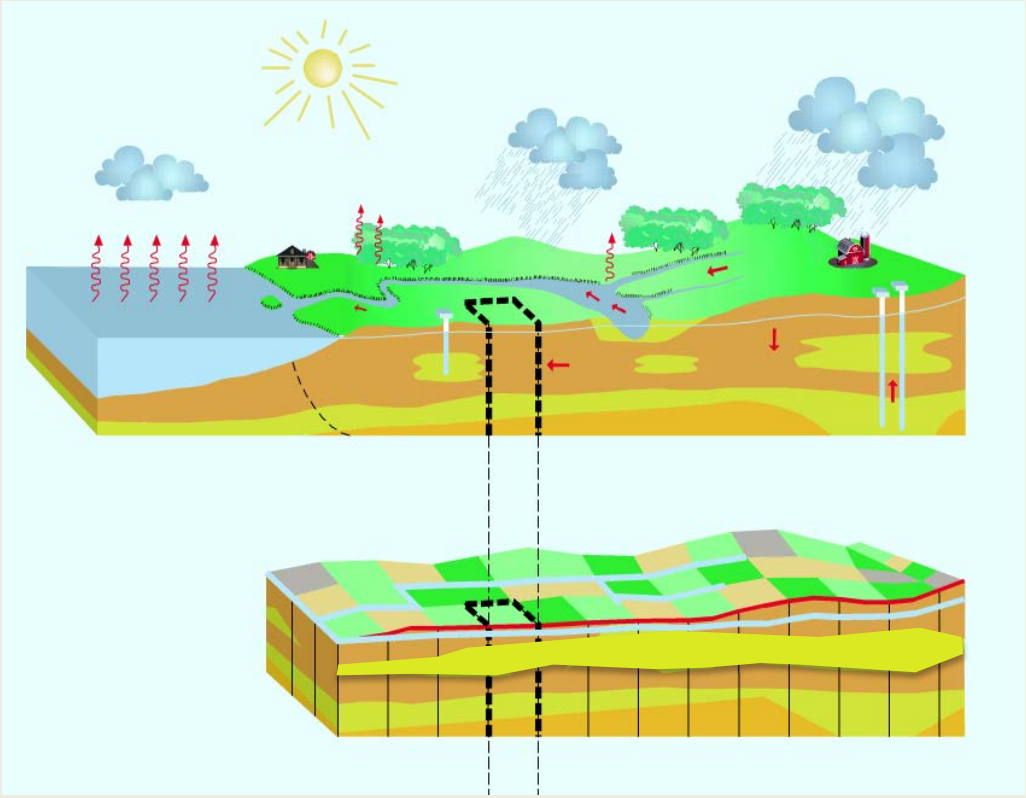
Indhold

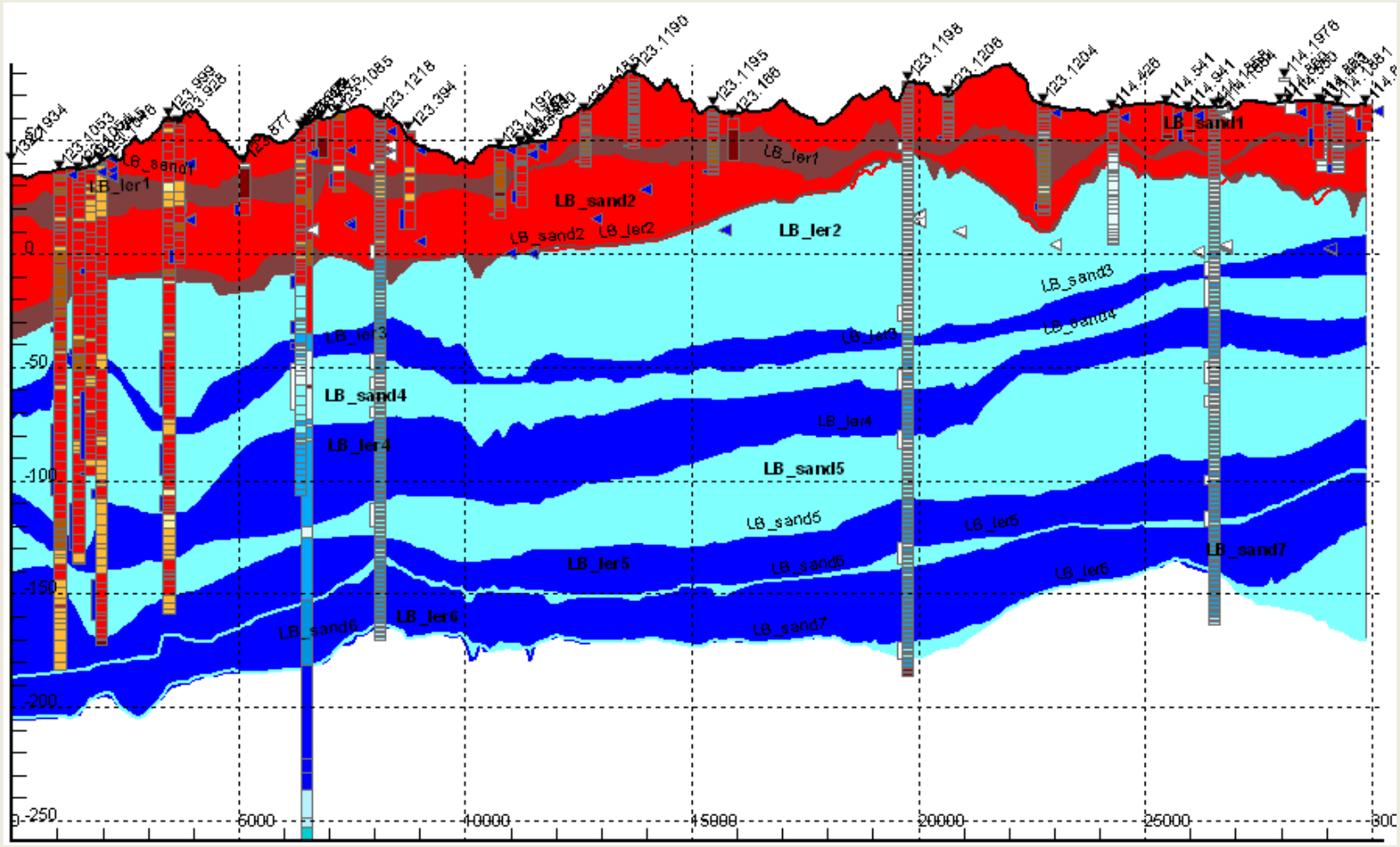
- Traditionel modellering
- Geofysiske data
- Geofysik: Mere info. om heterogenitet
  - NICA, KOMPLEKS, HYGEM
- Voxelmodellering
  - Geofysik → geologisk enhed → K-værdi
- Direkte bestemmelse af hydraulisk ledn.
  - Geofysik → K-værdi
- Konklusion

Geologisk model + Grundvandsmodel

1. Geologisk model
2. Beregnings-elementer
3. Grundvands-model

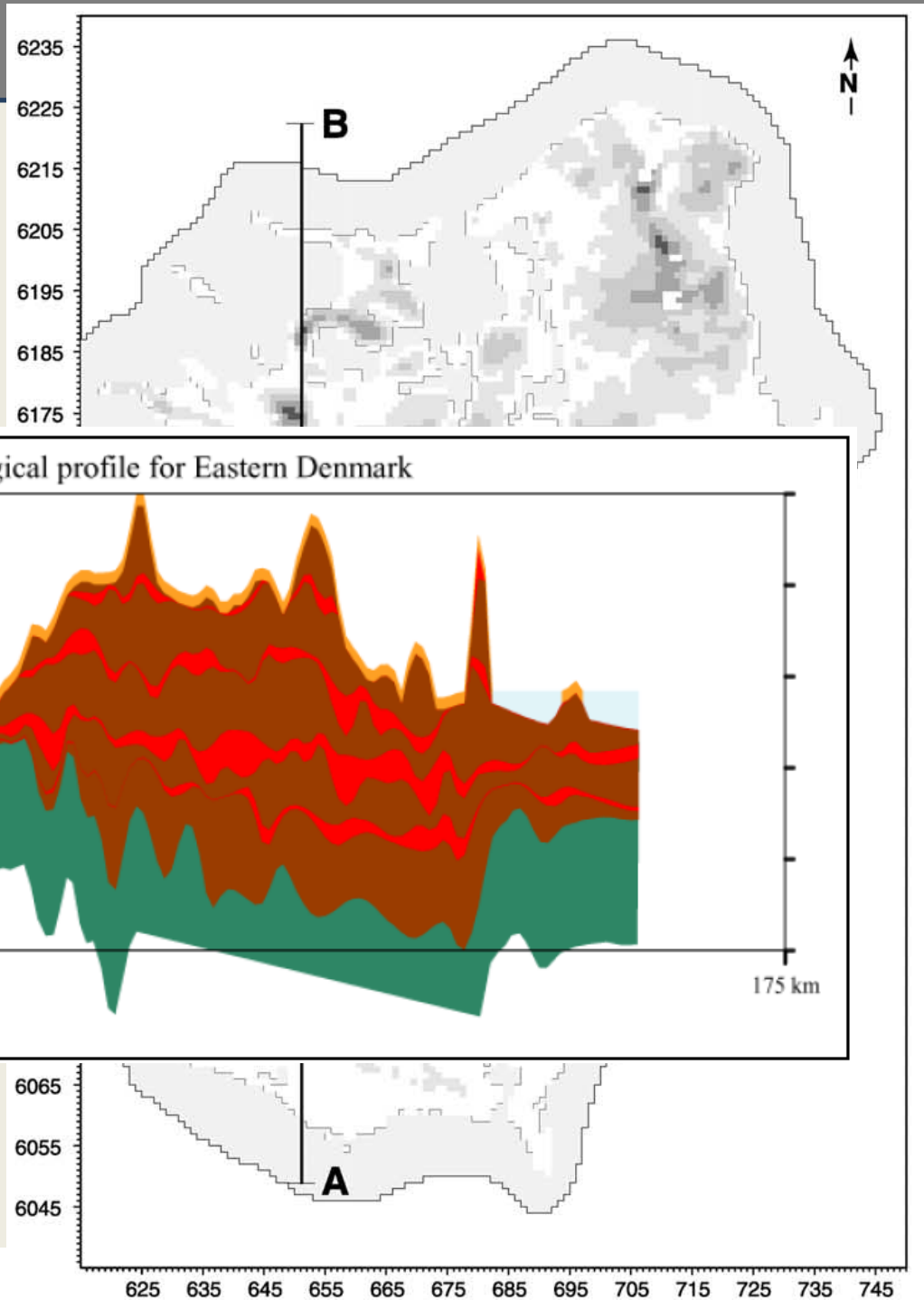


Traditionel tolkning: Lagmodel



Fra: Geovejledning #3

DK-model



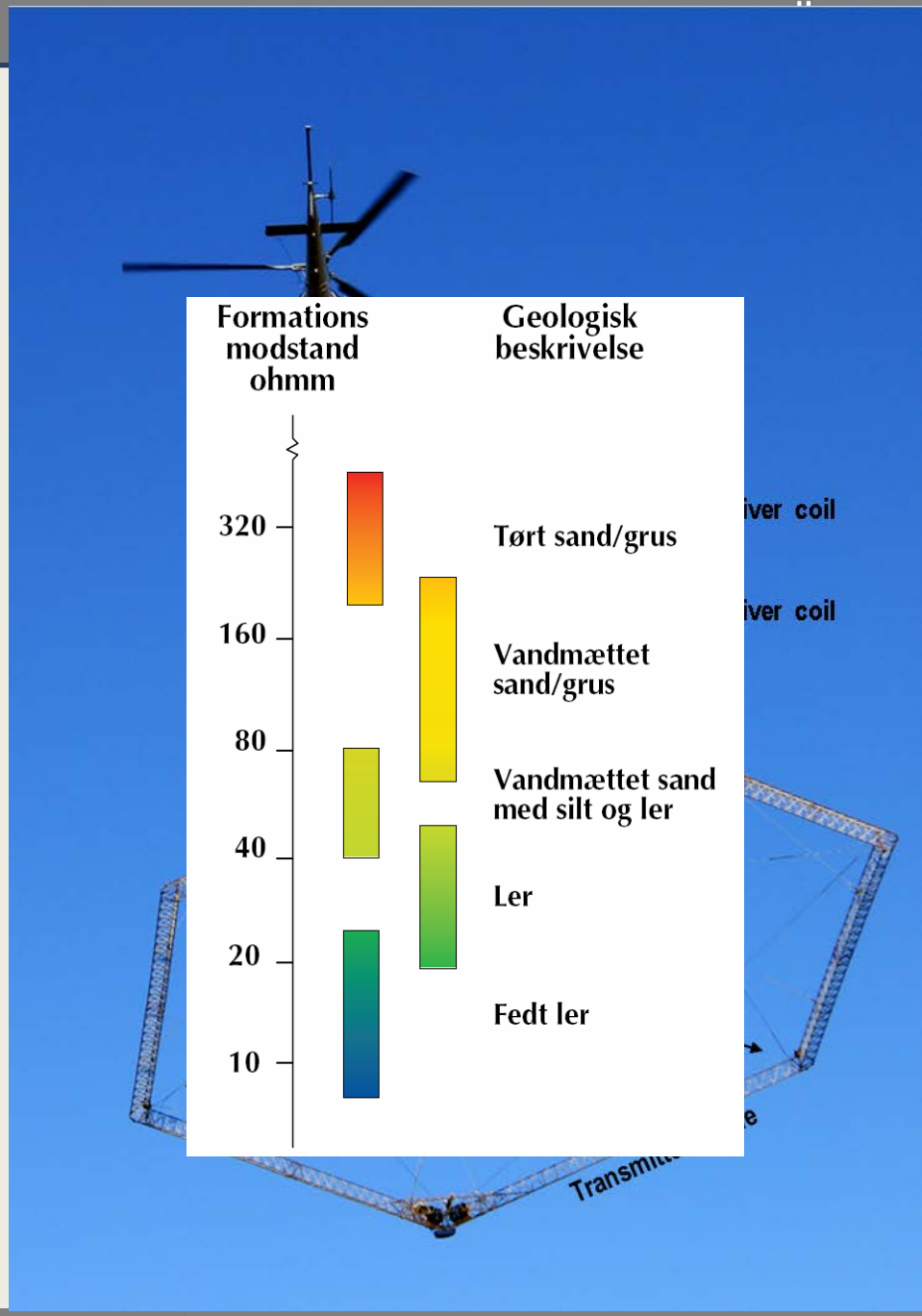
Henriksen et al. (2003)

Geofysiske data i grundvandskortlægningen

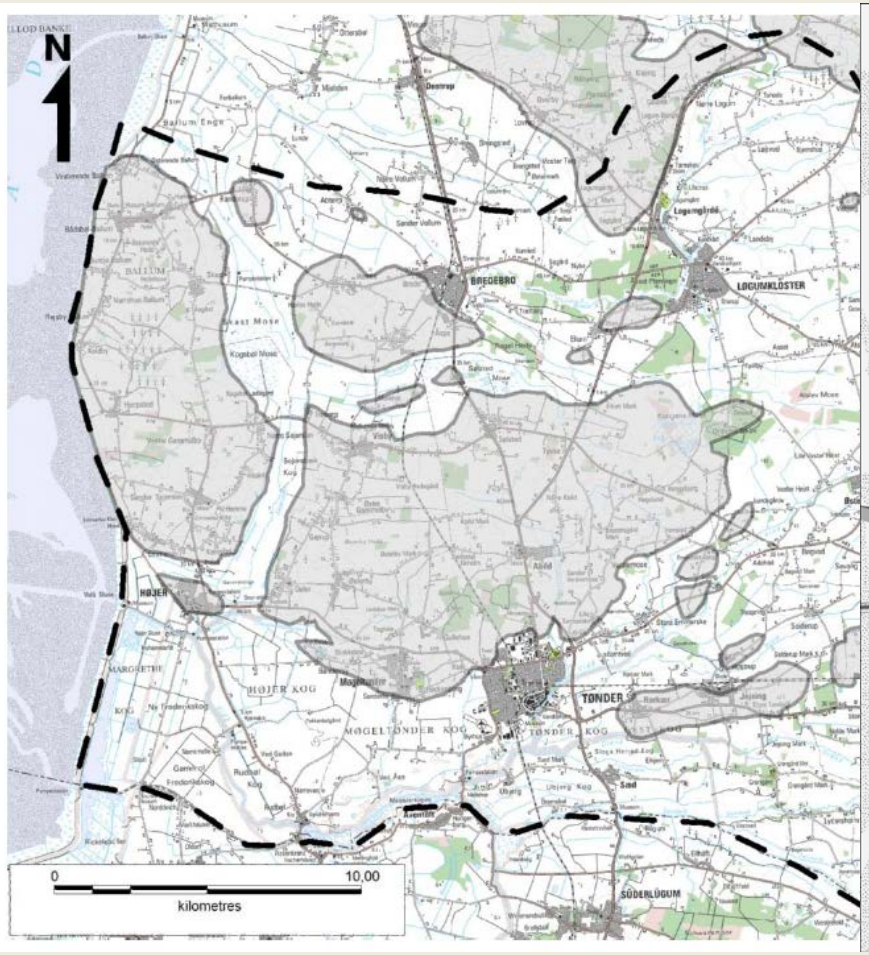
- Borehulsgeofysik (1D)
- Seismik (2D)
- TEM – SkyTEM (3D)
- MRS, PACES, MEP, Georadar, mm

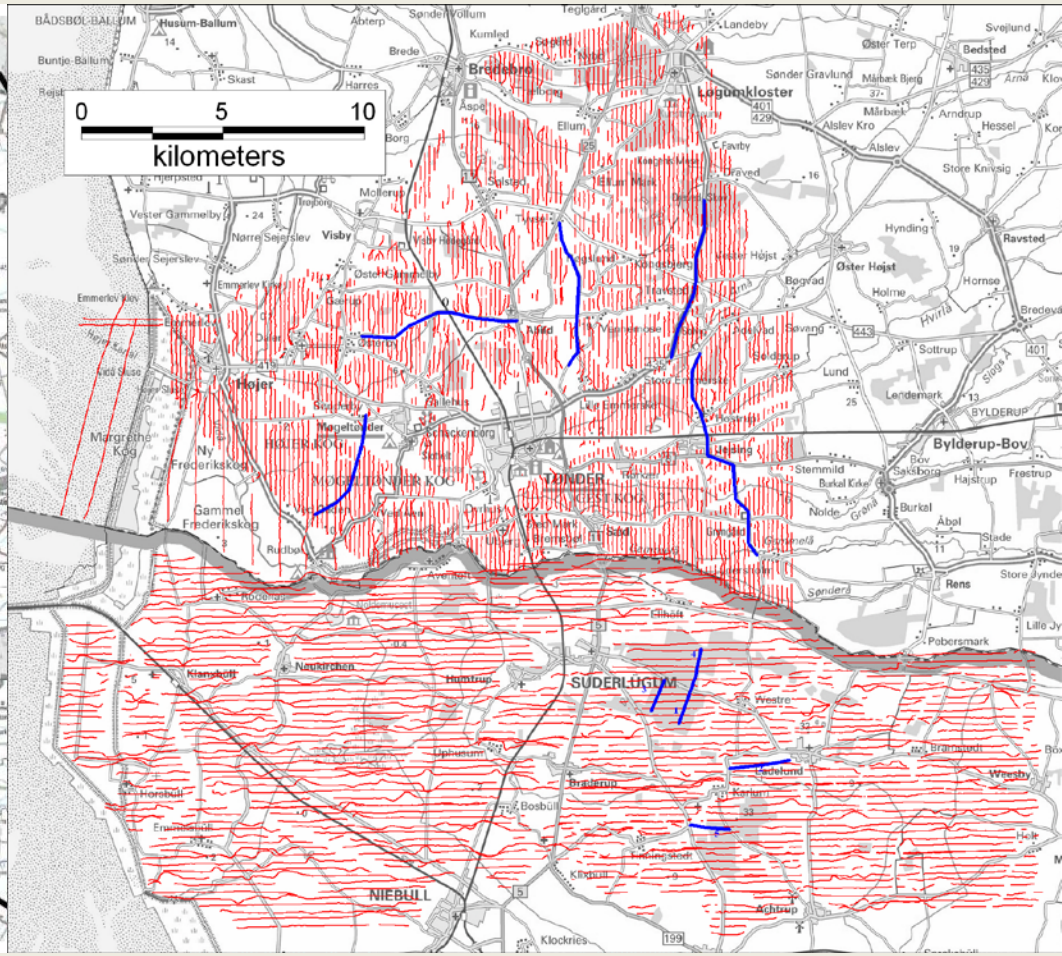
SkyTEM

- Kortlægger undergrundens elektriske modstand (ρ)
- Sammenhæng mellem modstand og litologi



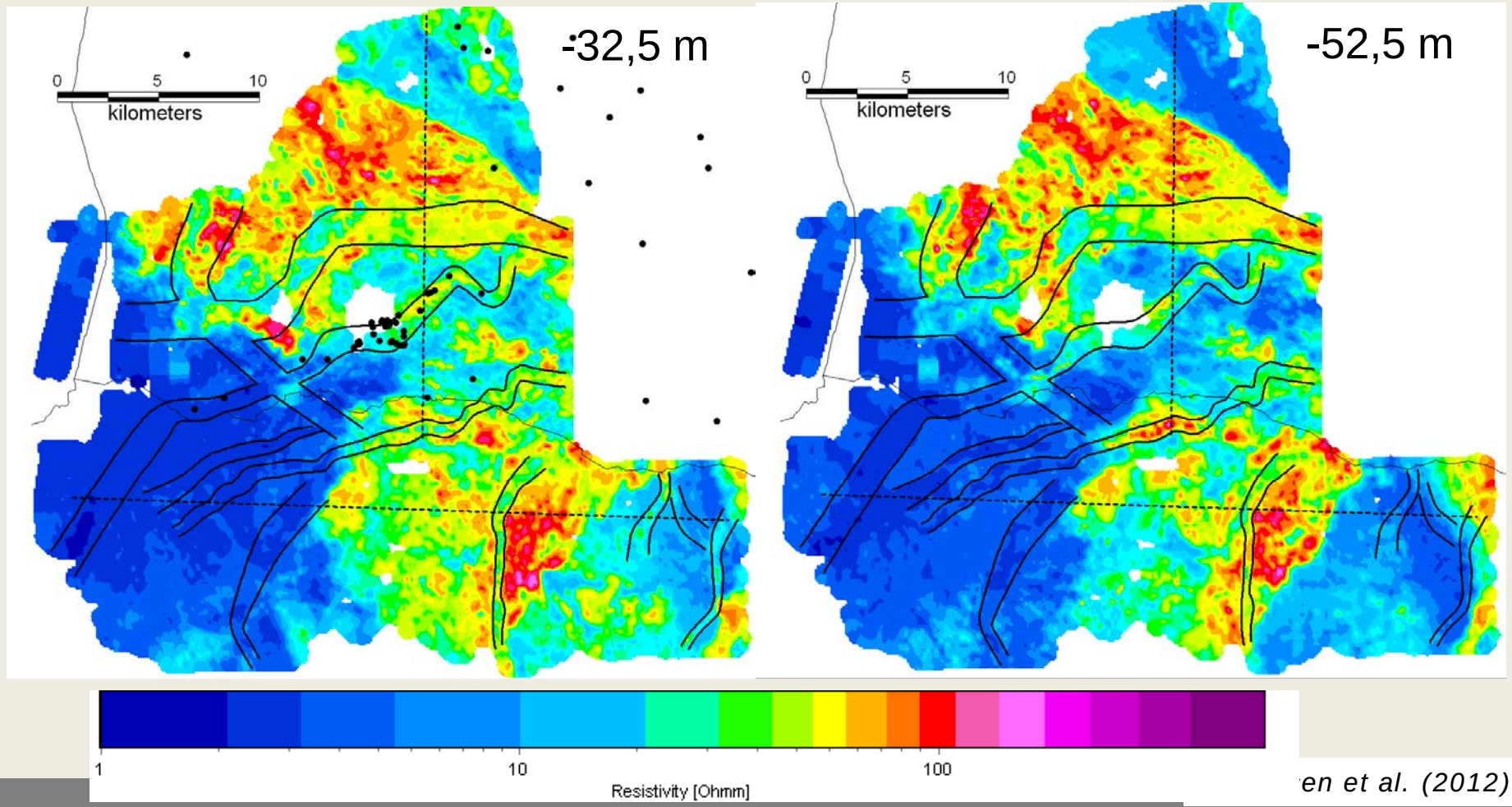
Tønder





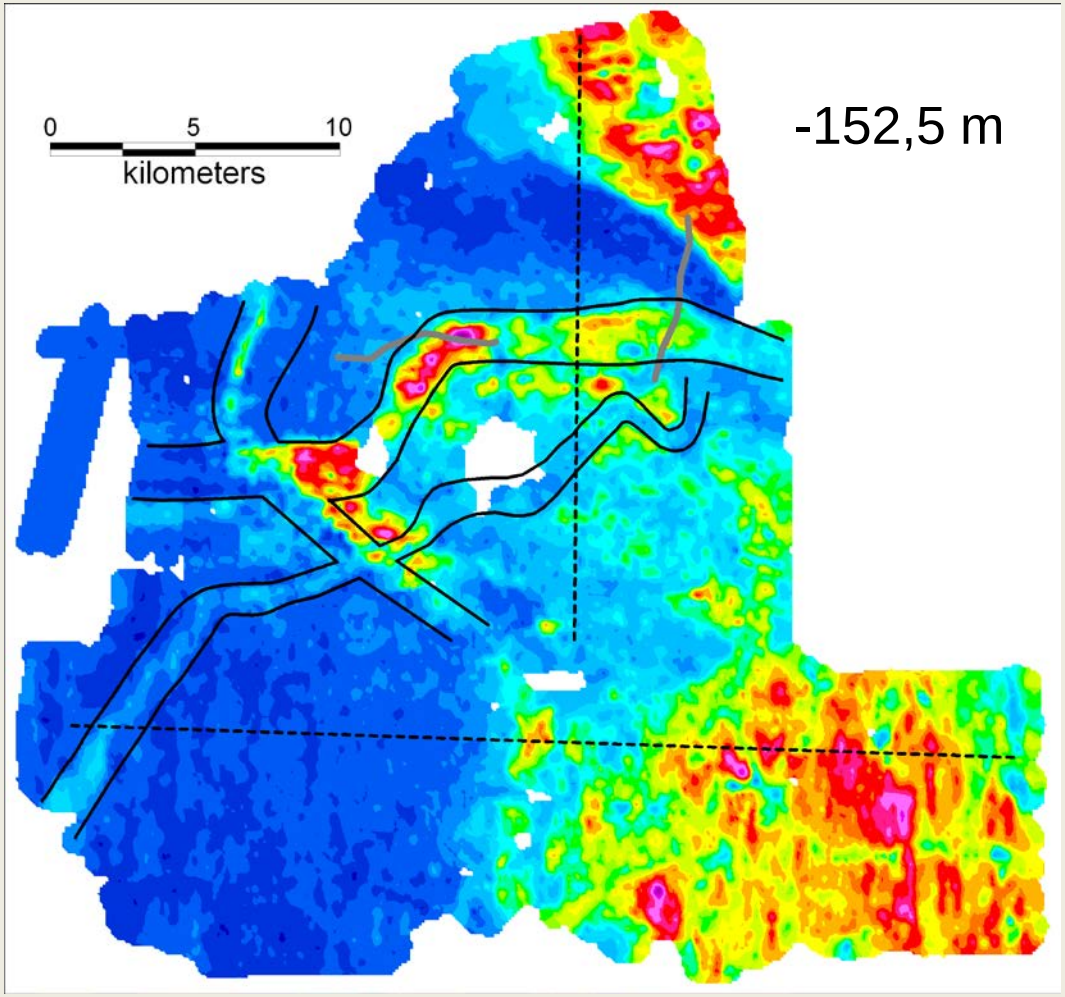
Jørgensen et al. (2012)

Resistivitets-fordeling



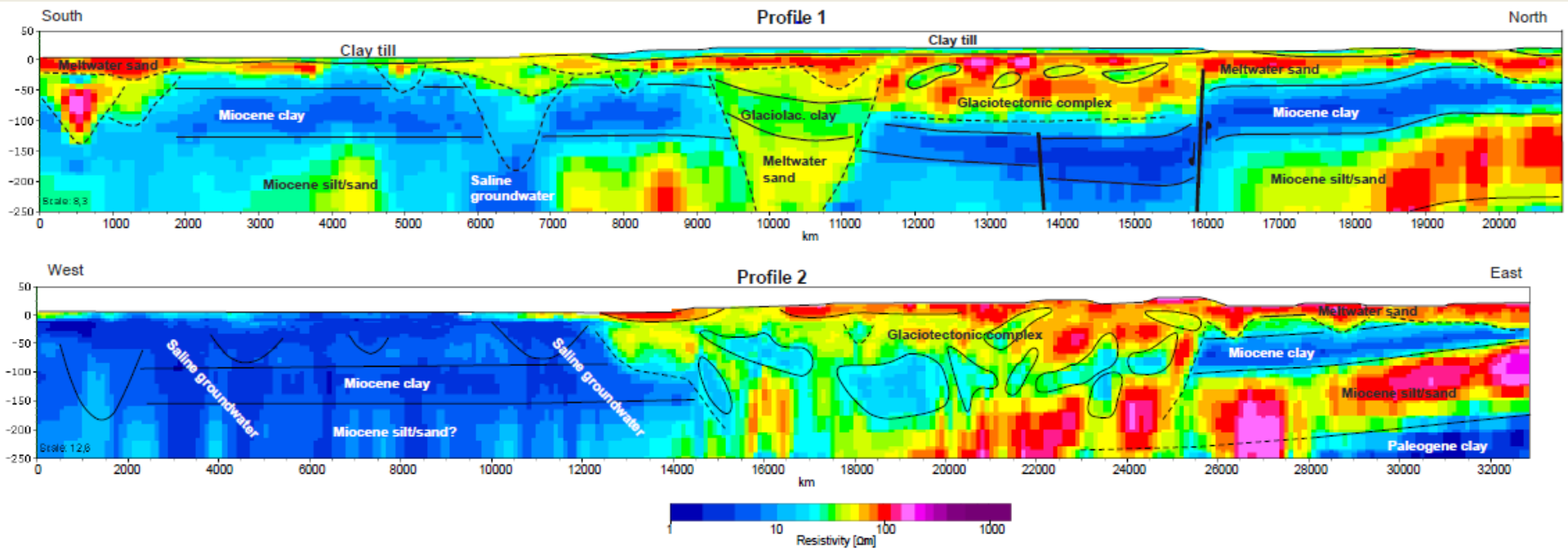
en et al. (2012)

Resistivitets-fordeling



n et al. (2012)

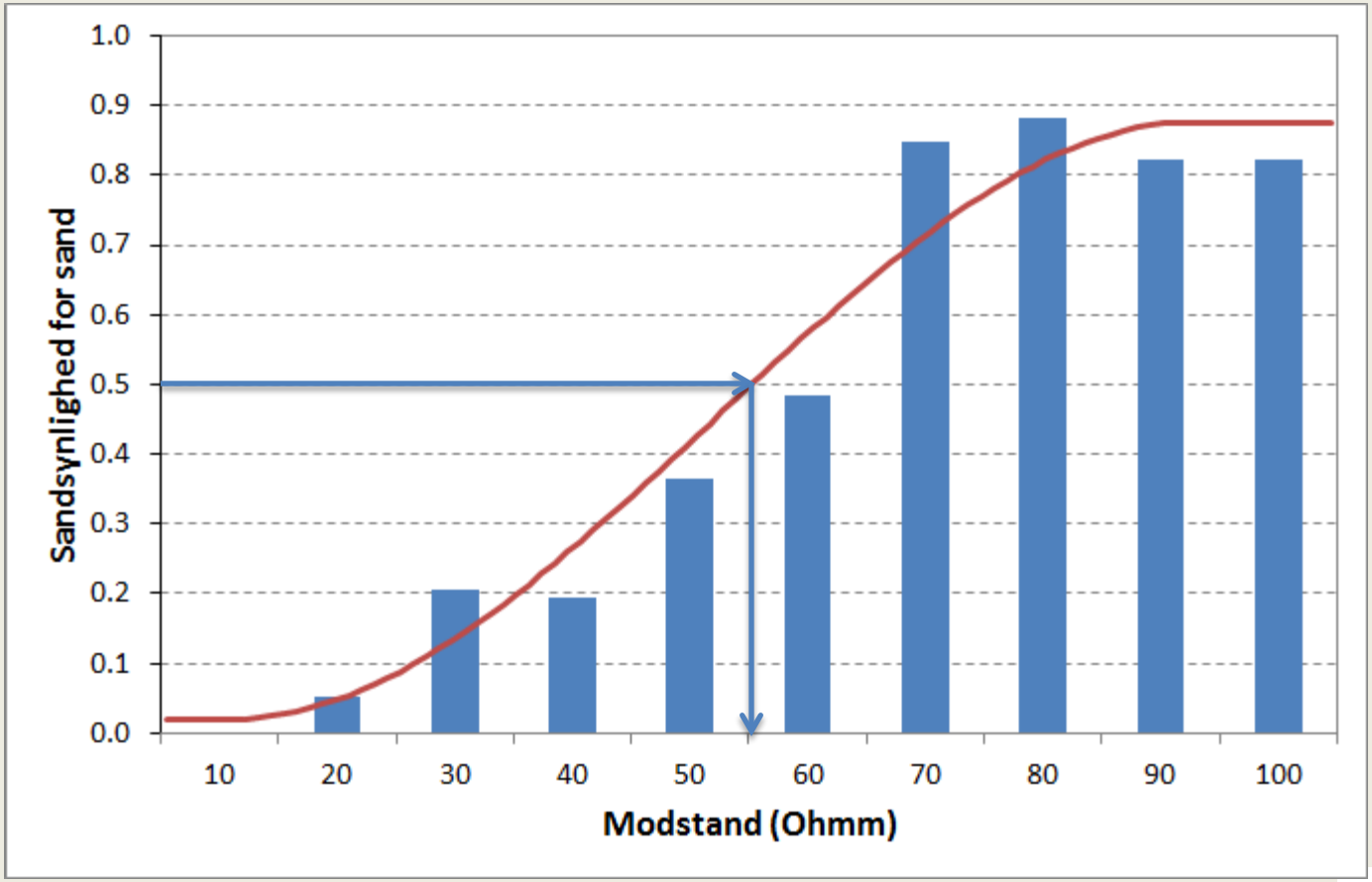
Resistivitets-fordeling



Jørgensen et al. (2012)

Tolkning i voxler (kasser)

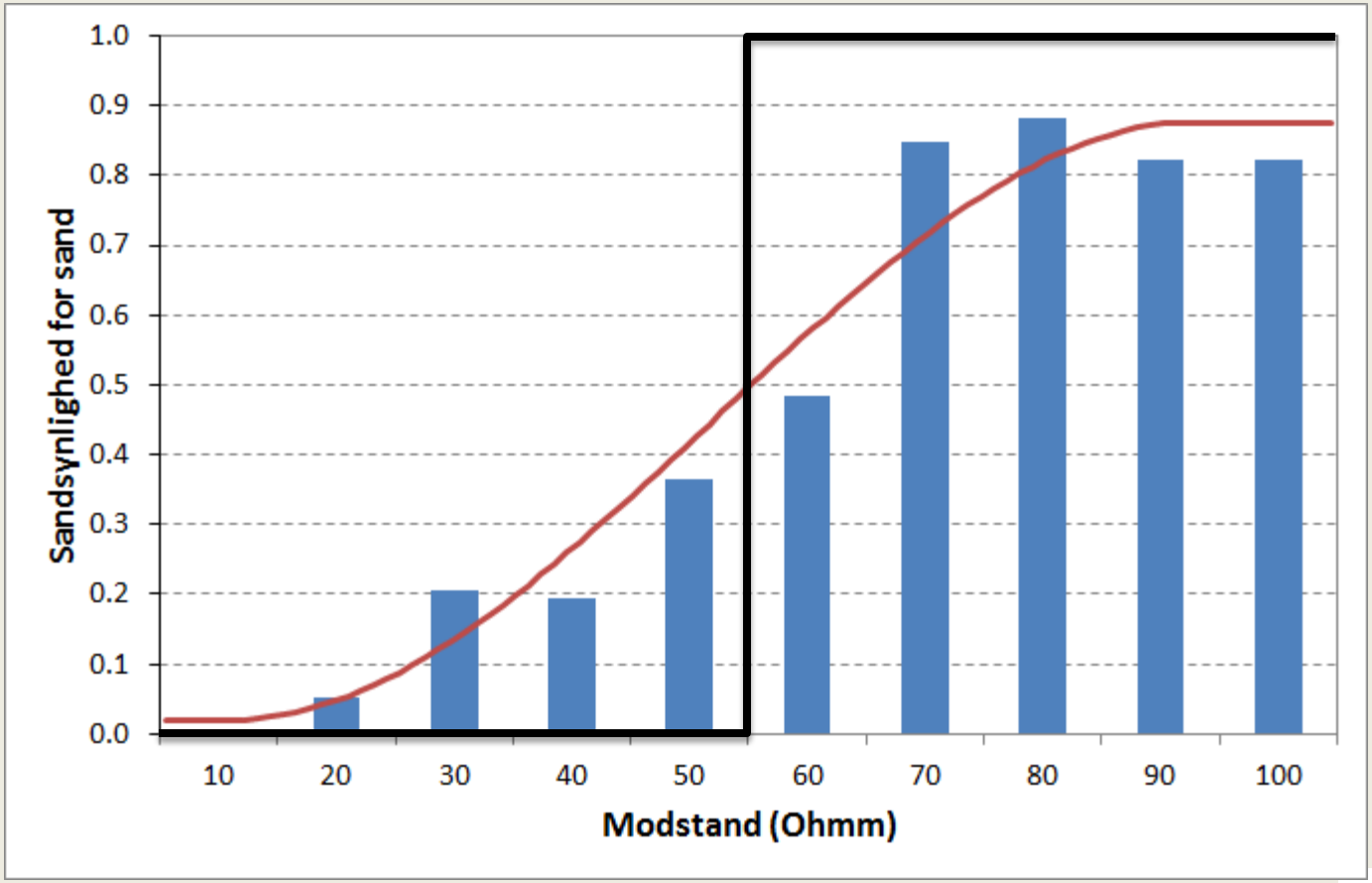
- Automatisk tolkning



He et al. (2014)

Tolkning i voxler (kasser)

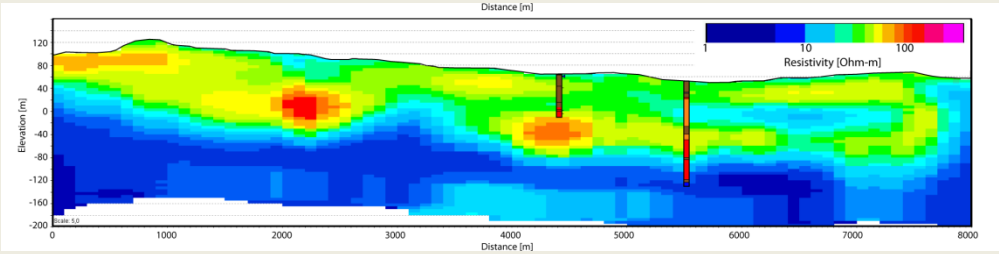
- Automatisk tolkning

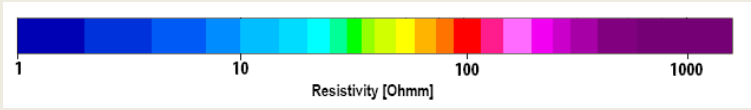


He et al. (2014)

Manuel vs automatisk tolkning

Modstandsprofil med boringer

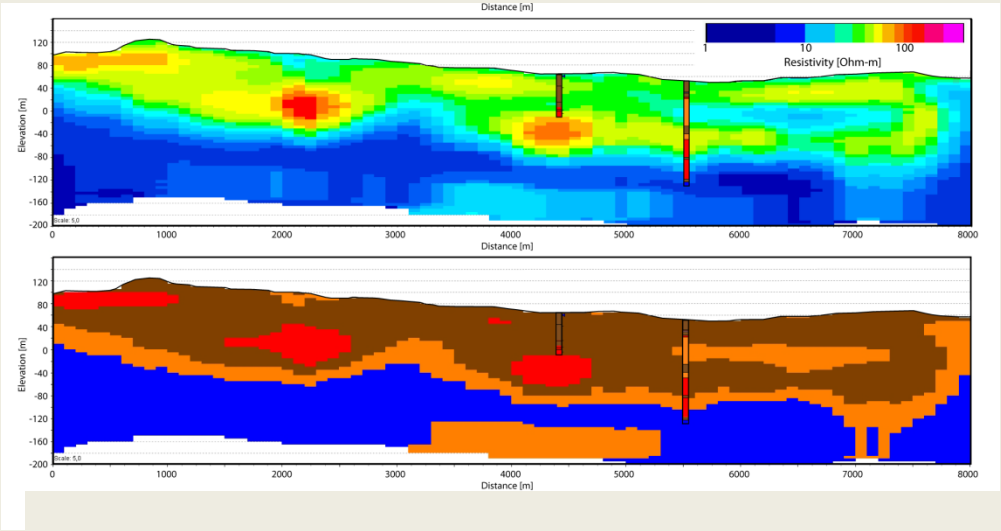




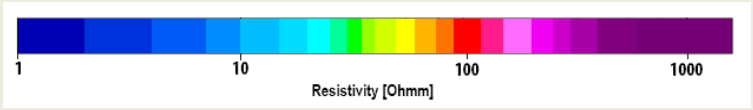
Jørgensen, F., Møller, R.R., Nebel, L., Jensen, N.-P., Christiansen A.V. and Sandersen, P.B.E. 2013: A method for cognitive 3D geological voxel modelling of AEM data. Bulletin of Engineering Geology and the Environment. Vol. 72, 3, 421-432. DOI: 10.1007/s10064-013-0487-2.

Manuel vs automatisk tolkning

Automatisk modelling / oversættelse



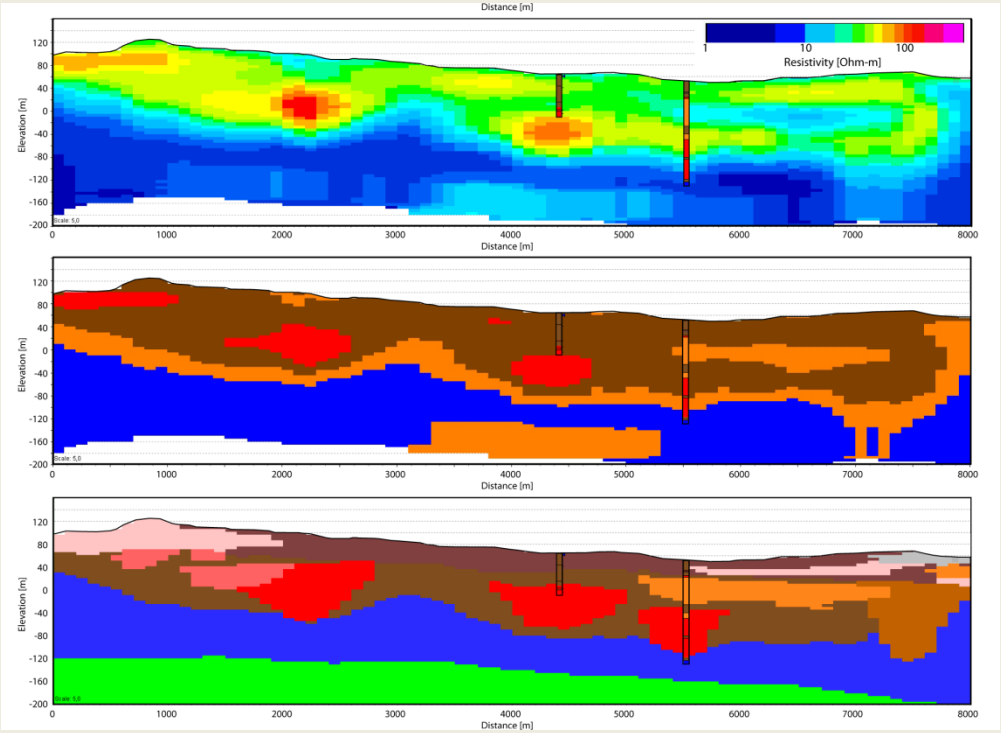
- < 8 ohmm = Palaeogen ler
- 8-25 ohmm = Smeltevandsler
- 25-55 ohmm = Moræneler
- > 55 ohmm = Smeltevandssand/grus

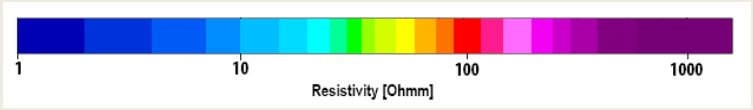


Jørgensen, F., Møller, R.R., Nebel, L., Jensen, N.-P., Christiansen A.V. and Sandersen, P.B.E. 2013: A method for cognitive 3D geological voxel modelling of AEM data. Bulletin of Engineering Geology and the Environment. Vol. 72, 3, 421-432. DOI: 10.1007/s10064-013-0487-2.

Manuel vs automatisk tolkning

Manuel (cognitiv) tolkning

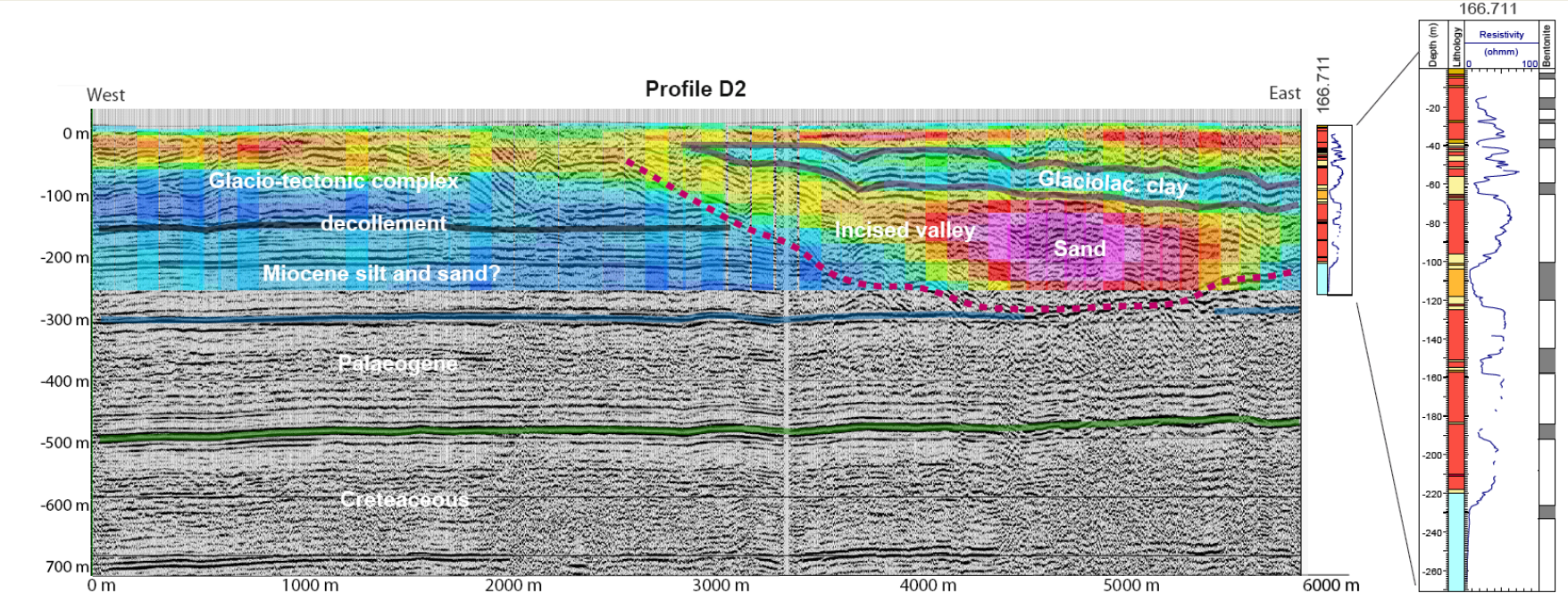




Jørgensen, F., Møller, R.R., Nebel, L., Jensen, N.-P., Christiansen A.V. and Sandersen, P.B.E. 2013: A method for cognitive 3D geological voxel modelling of AEM data. Bulletin of Engineering Geology and the Environment. Vol. 72, 3, 421-432. DOI: 10.1007/s10064-013-0487-2.

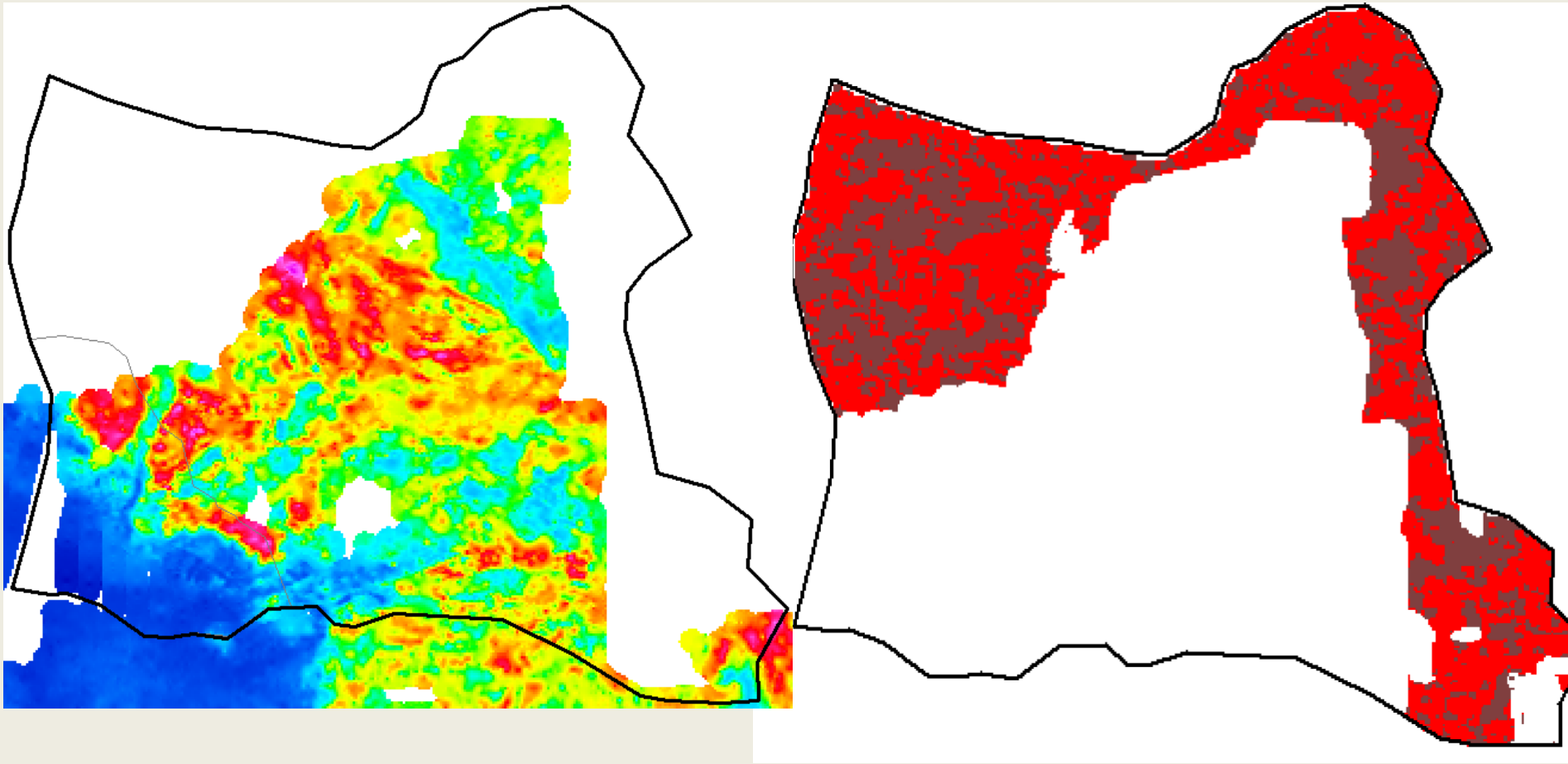
Manuel vs automatisk tolkning

Kombination af SkyTEM med andre datatyper



Jørgensen, F. et al. 2012: Transboundary geophysical mapping of geological elements and salinity distribution critical for the assessment of future sea water intrusion in response to sea level rise. Hydrology and Earth System Sciences, 1845-1862.

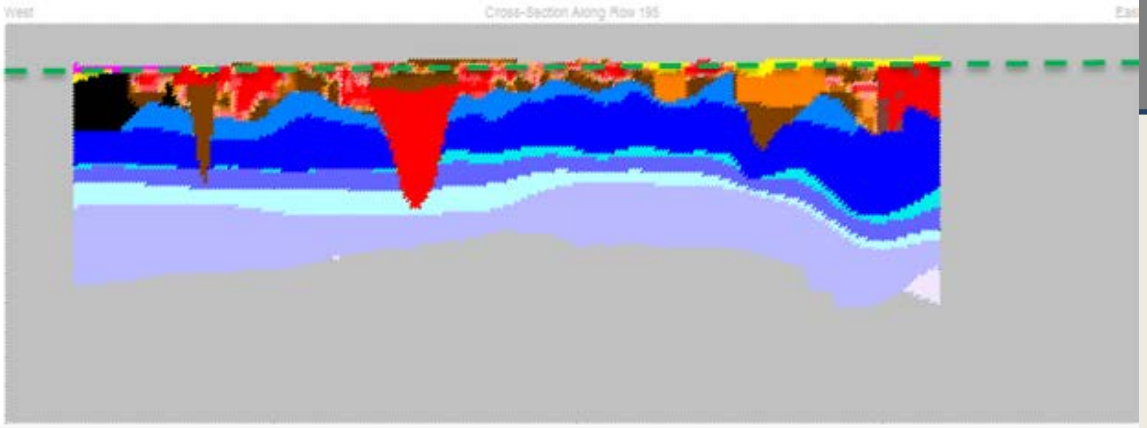
Resultat af voxelmodellering

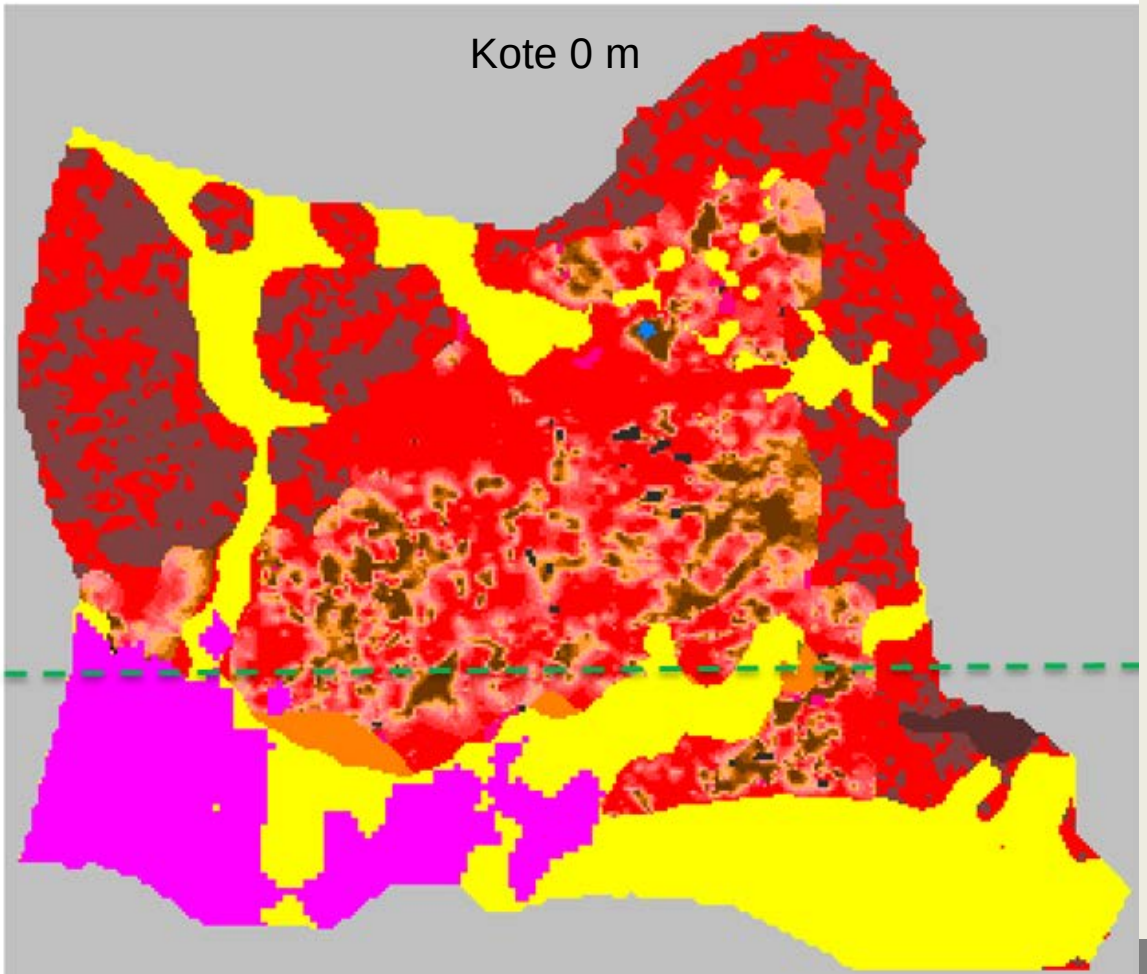


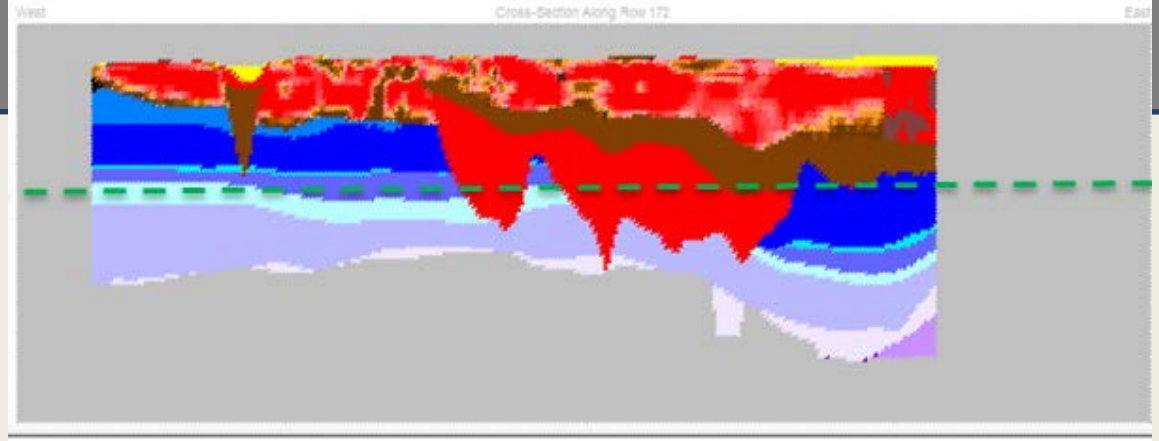
Geologiske enheder

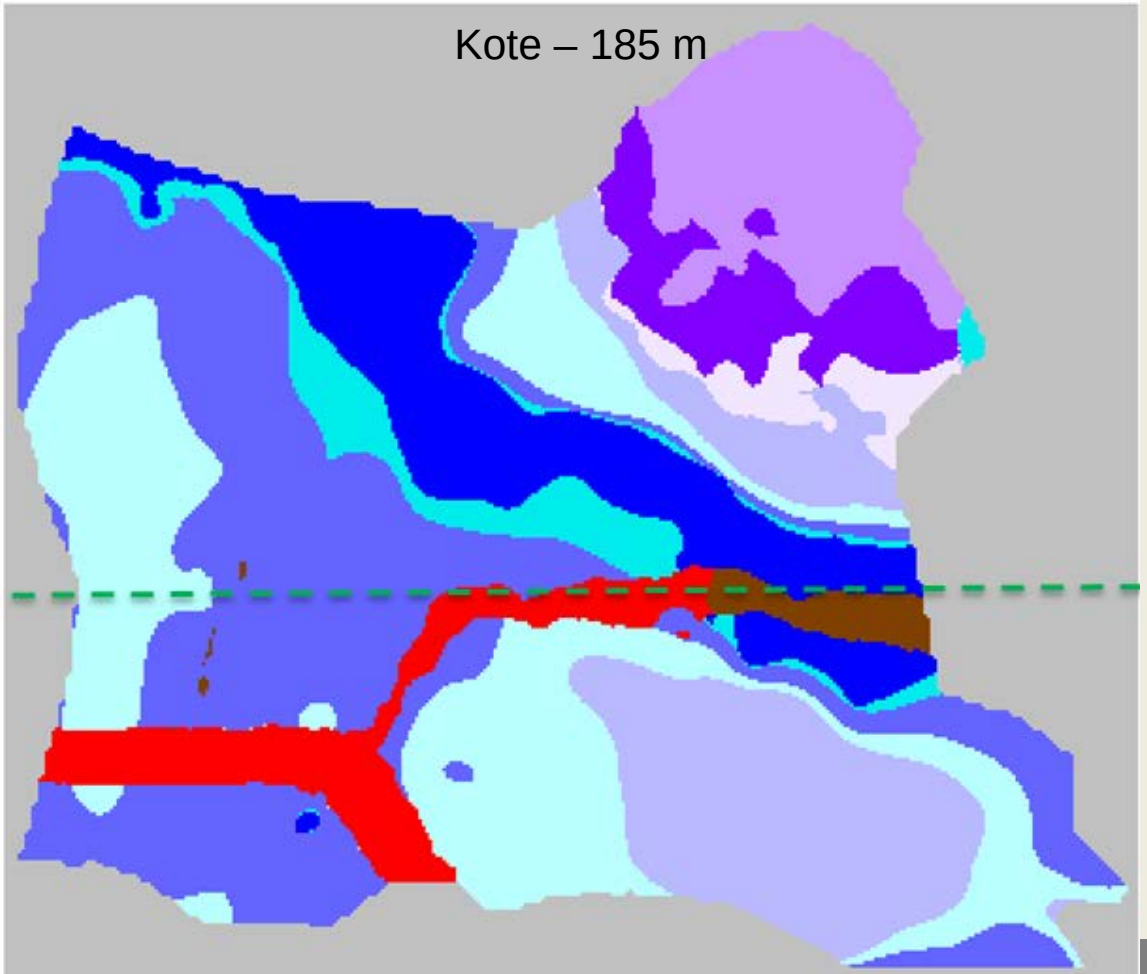
GV zoner	VALUE	CODE	Color	TEXT
1		id		not defined voxel
2	2	SGl		SGEMS clay
3	1	SGs		SGEMS sand
4	401	SV10		SSV 0-10%
5	402	SV20		SSV 10-20%
6	403	SV30		SSV 20-30%
7	404	SV40		SSV 30-40%
8	405	SV50		SSV 40-50%
9	406	SV60		SSV 50-60%
10	407	SV70		SSV 60-70%
11	408	SV80		SSV 70-80%
12	409	SV90		SSV 80-90%
13	410	SV100		SSV_100%
14	571	PG		Post_glacial
15	572	PS		Sandur
16	573	SG		Late_glacial
17	574	EM		Eem
18	586	MADe		MaadeGroup_deforme
19	576	MA		MaadeGroup
20	577	OD3		Odderup_S3

GV zoner	VALUE	CODE	Color	TEXT
21	578	AR3		Arnum_L3
22	579	OD2		Odderup_S2
23	580	AR2		Arnum_L2
24	585	KLI10		Klintinghoved_Clay_Upper_10
25	581	BAS		Bastrup_Sand
26	582	KLI9		Klintinghoved_Clay_Lower_9
27	601	qs		Quaternary_Sand
28	602	ql		Quaternary_Clay
29	590	LG1_DS		Abild_Valley_Sand
30	591	Clay		Abild_Valley_Clay
31	593	SAND		Hoejer_Valley_Sand
32	592	Clay		Hoejer_Valley_Clay
33	595	Clay		Toender_Jejs_Valley_Clay
34	596	SAND		MoegelToender_Valley_Sand
35	597	Clay		MoegelToender_Valley_Clay
36	599	SAND		Toender_Jejs_Valley_Sand_Upper
37	603	QsedSA		QuartenarySediments_Saltwater
38	598	SAND		LoegumKloster1_Valley_Sand
39	622	Q_MC		Q_MC
40	625	SAND		MoegelToender Valley Upper Sand



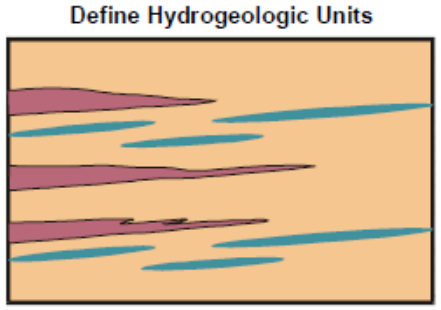

Kote 0 m

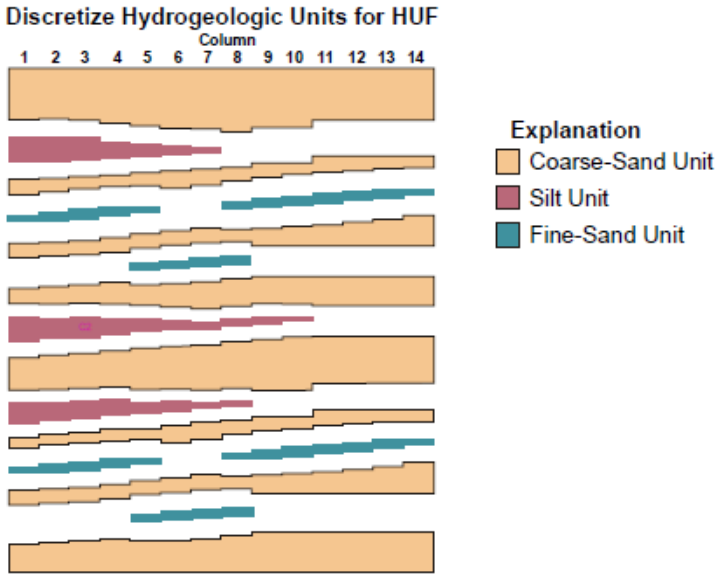

West
Cross-Section Along Row 172
East

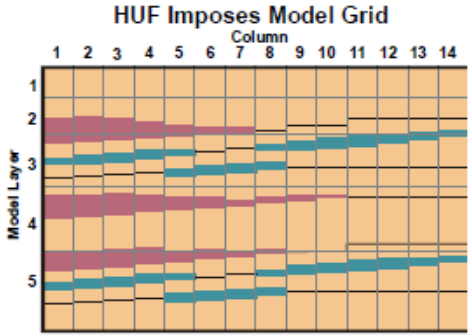

Kote – 185 m

Tolkning i voxler

- Grundvandsmodel
  - MODFLOW
  - MIKE SHE







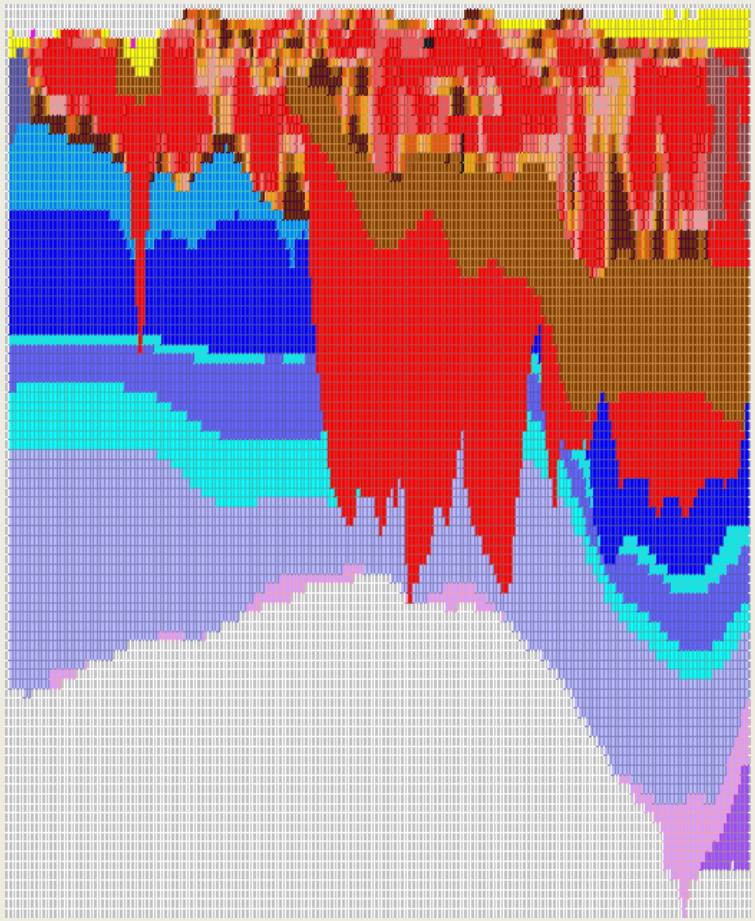
Hydrogeologisk model

- I alt 3,973,000 voxler fordelt på 40 geologiske enheder
- Reduceret til 8 hydrogeologiske enheder

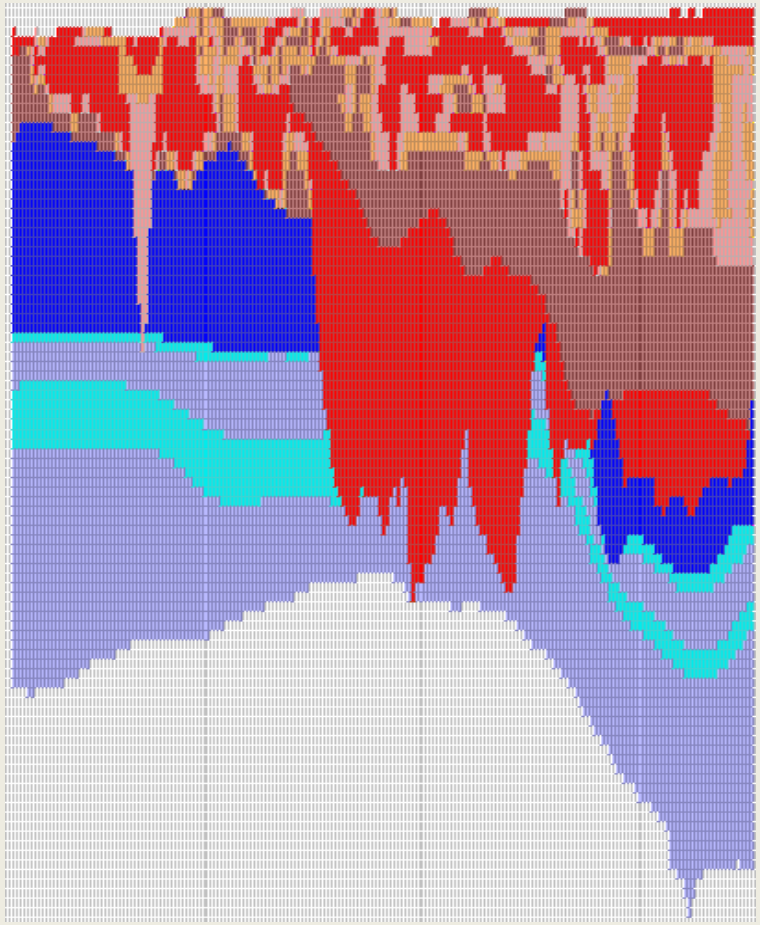
	Kvartært ler		Prækvartært ler		Kvartært sand		Prækvartært sand	
Enhed	1: QCH	2: QCL	3: PCH	4: PCL	5: QSH	6: QSL	7: PSH	8: PSL
Antal voxler	293.573	184.773	1.476.399	652.820	407.059	365.011	116.329	478.043

Hydrogeologisk model

Geologisk model

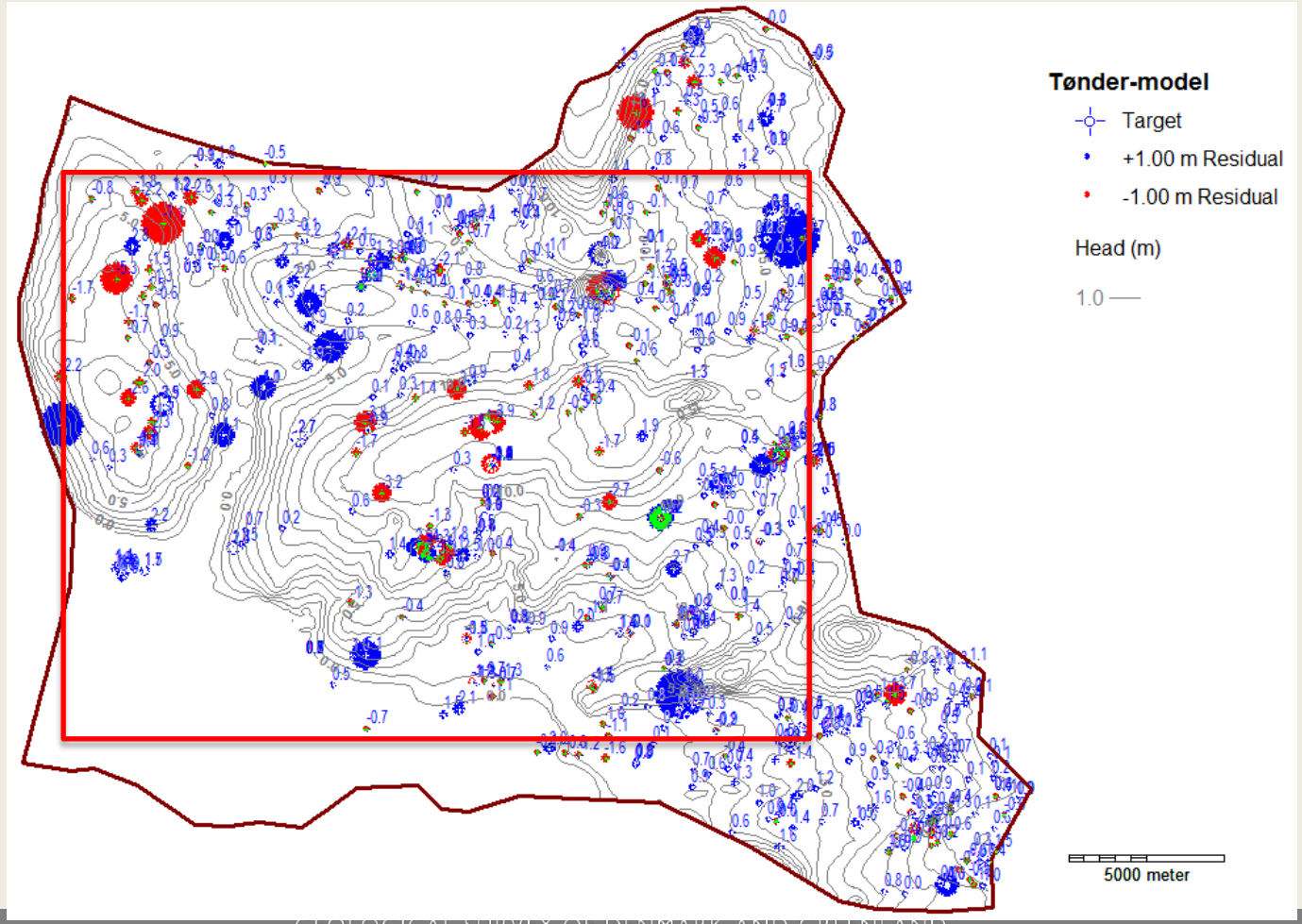


Hydrogeologisk model

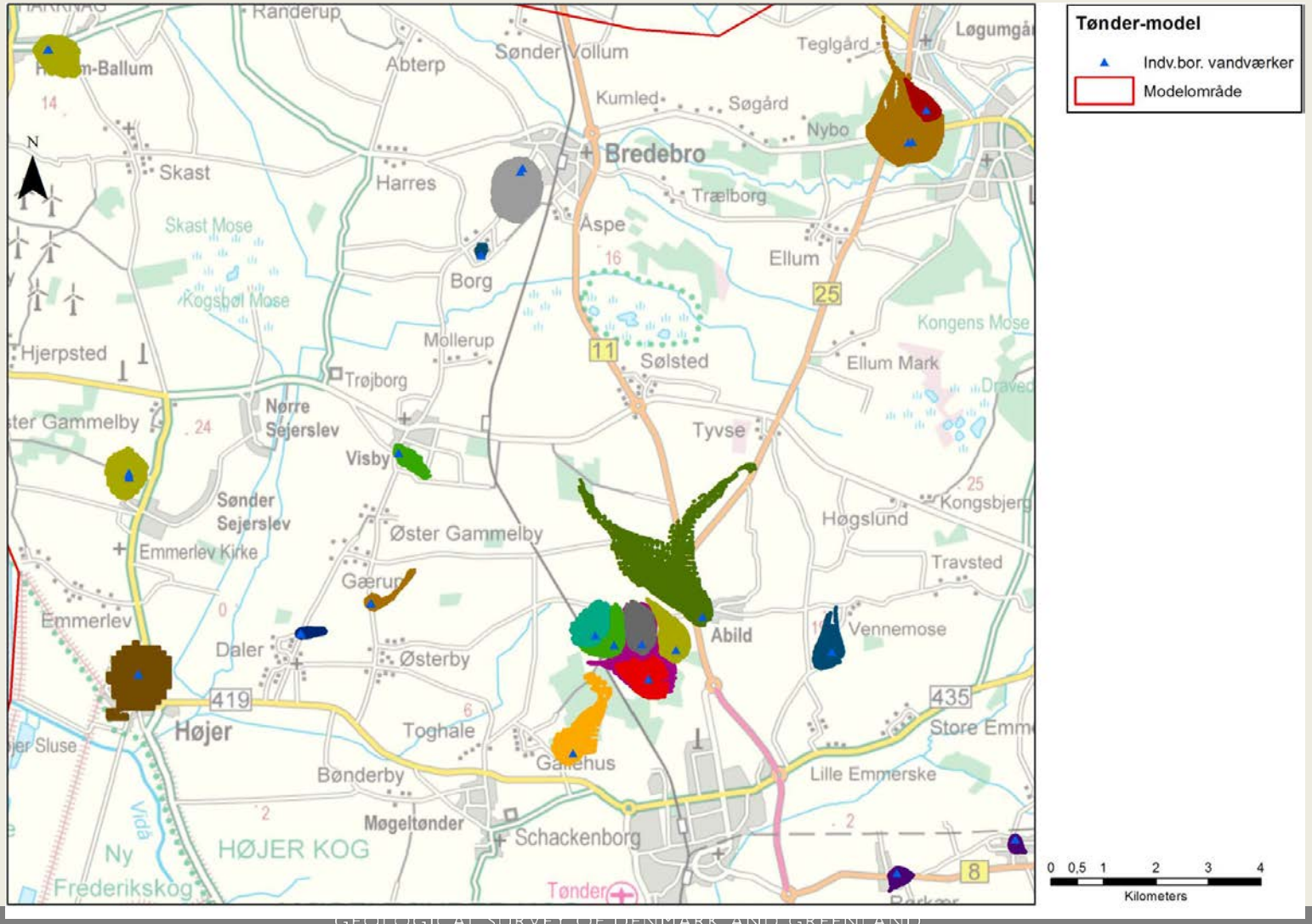


Kalibrering

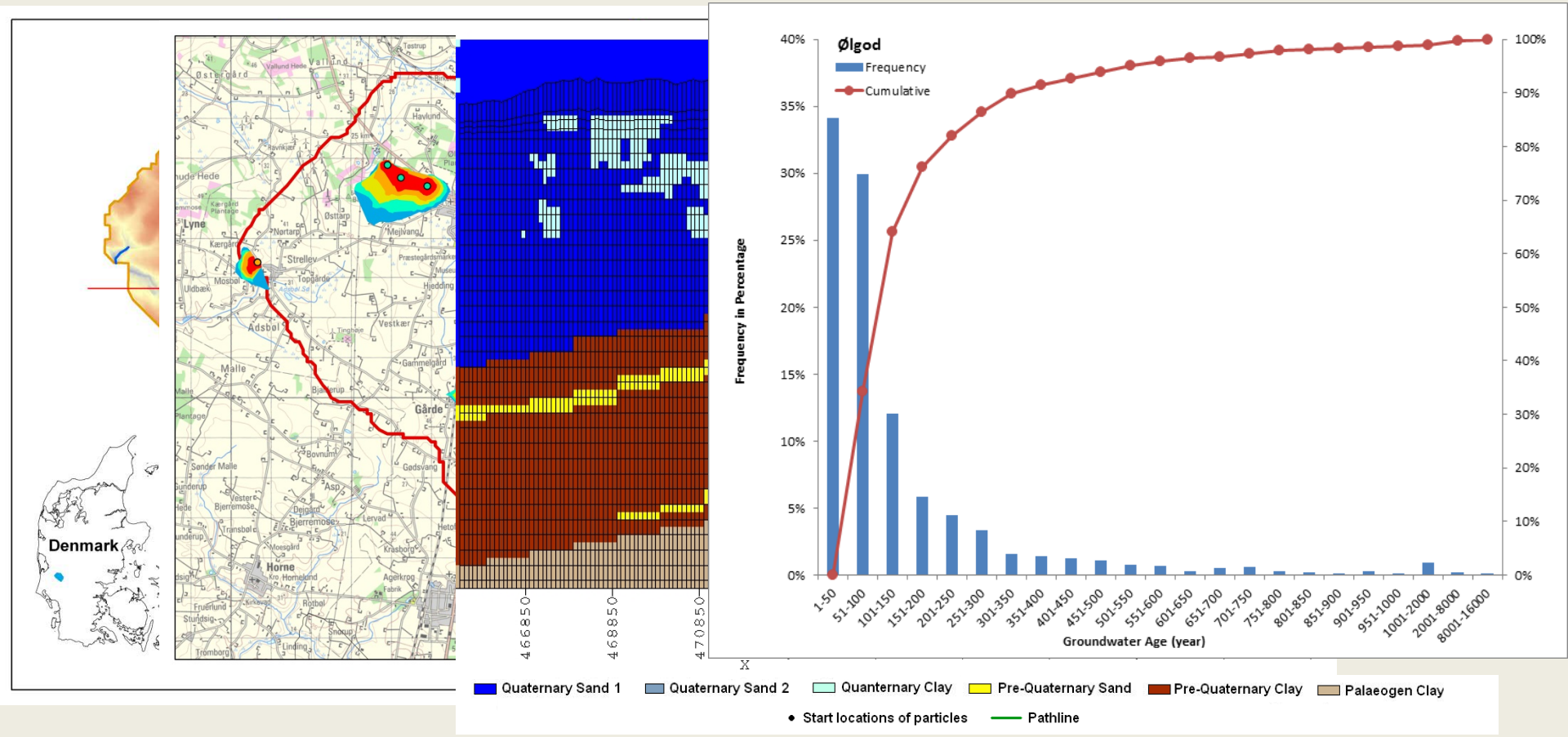
- Observeret – beregnet grundvandsstand



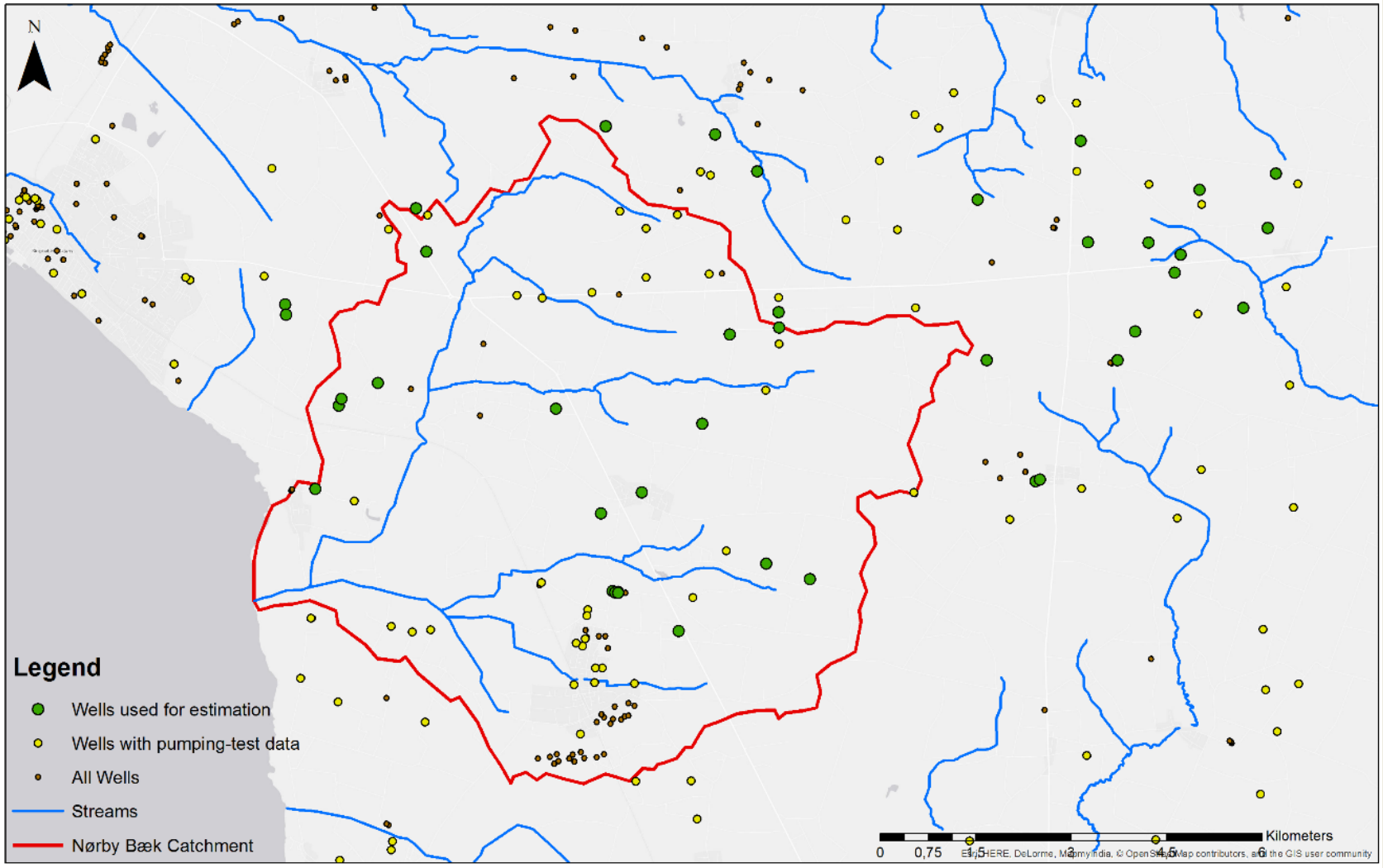
Indvindingsoplande - Tønder



Indvindingsoplande - Ølgod

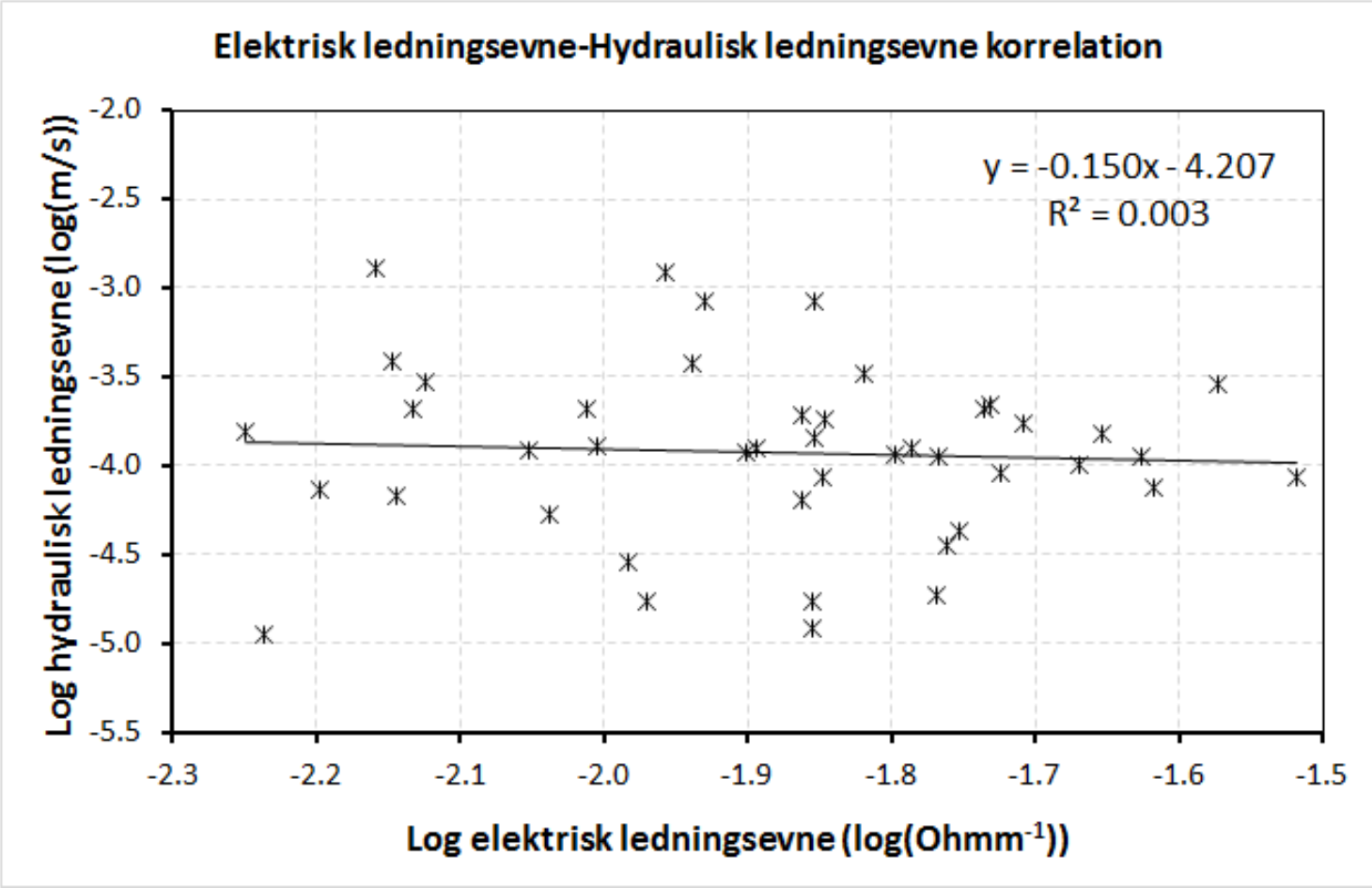


Sammenhæng mellem ρ og K



Fra: Jantzen (2014)

Sammenhæng mellem ρ og K (sand)



Konklusion

- Voxel-metode udnytter informationen i geofysik data bedre end lagmodellering
- Giver bedre beskrivelse af geologi – specielt heterogenitet beskrives bedre
- Heterogenitet vigtig for strømningsveje
- Vigtig for udpegning af sårbare områder

- Forudsætter høj densitet af data (eller statistisk model)
- Sammenligning af lagmodel og voxelmodel mangler