First results of the tTEM surveys

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Aarhus University, Denmark

Content

- **Motivation**
- **tTEM system – how does it work?**
- **Topsoil extension activities**
- **Development of the system during the Corona lockdown**
  - Increasing the signal to noise ratio
  - The 3x3 system
  - Realtime interpretation
- **First results**
  - Germany
  - Netherlands
  - Belgium
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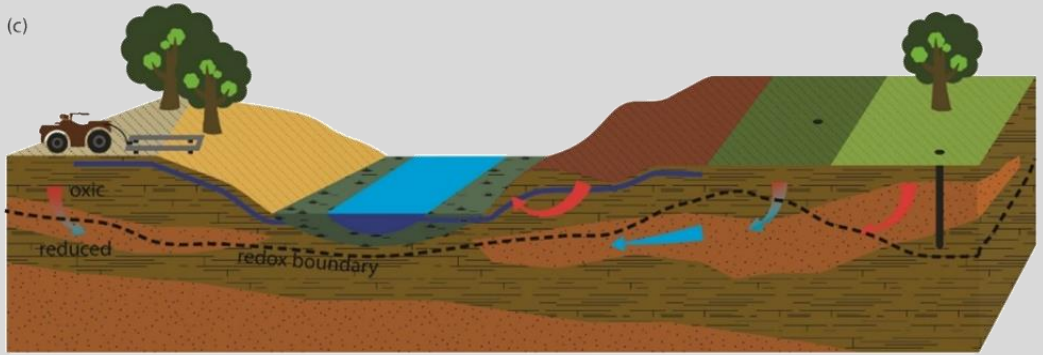
Motivation

- **Development driven by need for effective tool to describe the following on hectar scale:**
  - Surface-/Groundwater interaction (geologic structures, aquifer resource and vulnerability mapping)
  - Geotechnical applications
  - Raw materials
  - Point source pollution
- **Need for**
  - High resolution
  - Areal coverage
  - Fast and cost effective



Motivation – current toolbox?

- **Airborne TEM-systems**
  - \+ Fast, effective, high depth of investigation
  - ÷ Large footprint, coarse resolution

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  - \+ High resolution, well-documented
  - \- Ineffective

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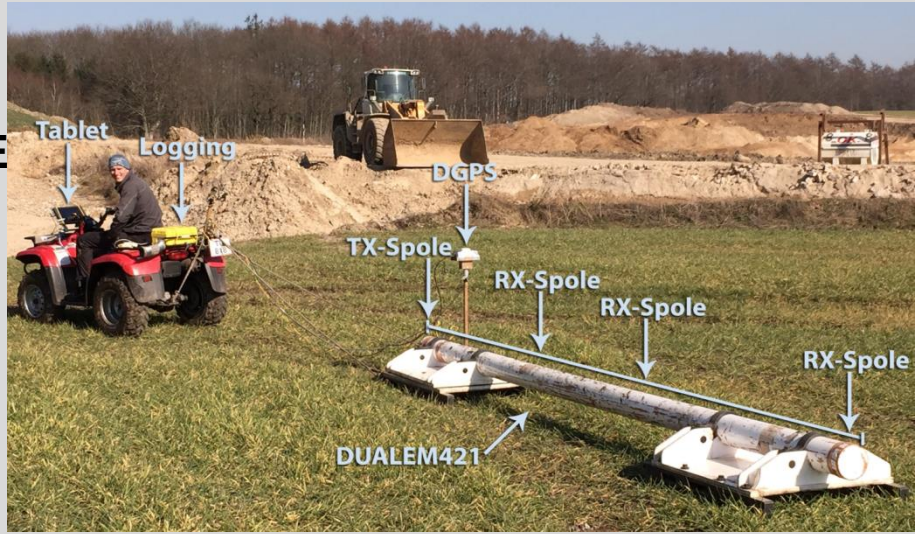
  - - Ineffective
- **Ground Conductivity Meter (GCM)**
  - + Effective, high resolution
  - - Poor depth of investigation



Motivation – current toolbox?

- **Airborne TEM-systems**
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- **Electrical Resistivity Tomography (ERT/MEP)**
  - \+ High resolution, well-documented
  - \- Ineffective
- **Ground Conductivity Meter (GCM)**
  - \+ Effective, high resolution
  - \- Poor depth of investigation
- **tTEM**
  - \+ Effective, small footprint, high resolution
  - \+ Shallow and intermediate depth of investigation

towed Transient Electro Magnetic system

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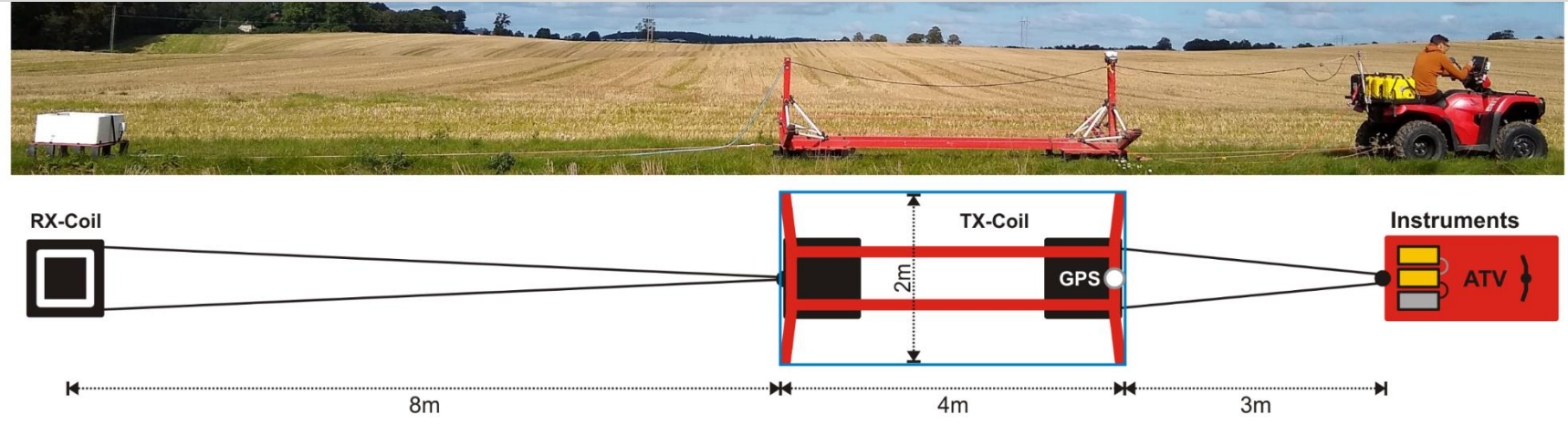
tTEM system - design



- 10-20 km/h ~ 3-5 m/s
- Measurements takes few milliseconds (3-10 m lateral resolution), 10-30 m line distance = 3D!!
- Depth of investigation of 0-100 m
- Best resolution in the upper 30 m
- Map 50-200 hectares per day

tTEM system - technical details

- **Real-time interpretation and navigation software to plot mapping lines etc.**
- **Data processering og inversion software fully integreted with system (Aarhus Workbench)**
- **4G network**

tTEM – a Towed TEM system for Detailed 3D Imaging of the Top 70 meters of the Subsurface: Geophysics. Auken, E., Foged, N., Larsen, J. J., Lassen, K. V. T., Maurya, P. K., Dath, S. M., and Eiskjær, T., 2018,

tTEM system - what do we measure?

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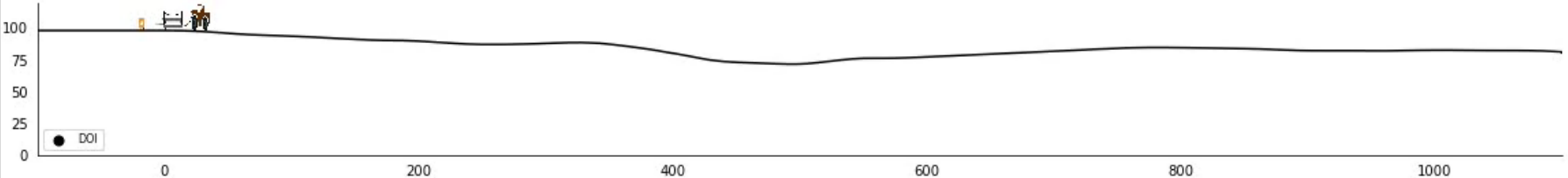

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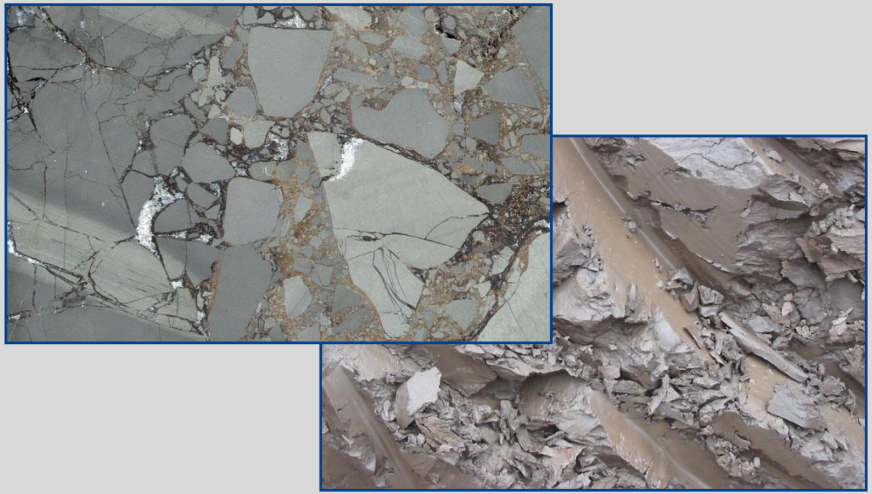
tTEM system - what do we measure?

Resistivity of geologic materials

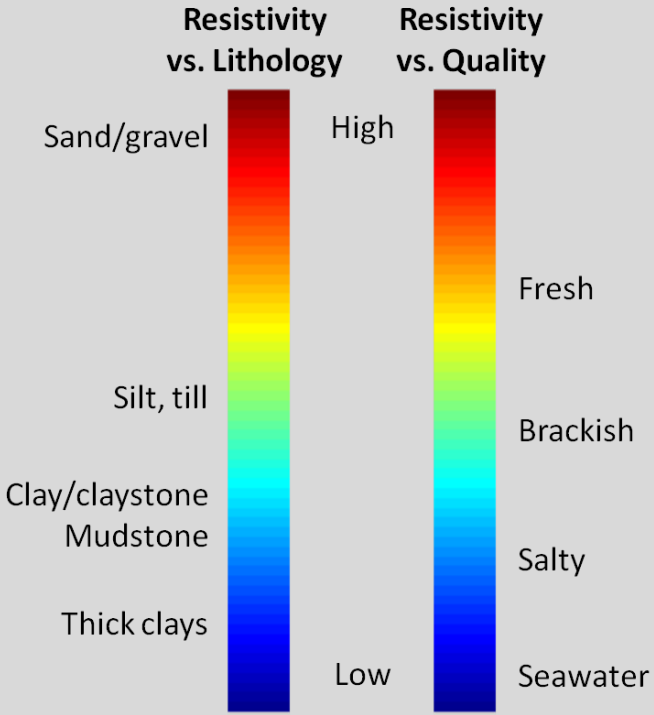
- Sediment type – sand or clay (or a mixture)
- Ion content of the pore water
- Clay type
- Porosity and Saturation



tTEM system – what do we measure?

- **Hydrogeophysical investigations:**

Low Resistivity	High Resistivity
Saturated	Unsaturated
Clay	Sand
Saltwater	Freshwater
Contaminated	Uncontaminated



tTEM system

- **tTEM – open landscape**
- **FloaTEM – lakes, rivers and shallow saltwater**
- **SnowTEM – permafrost**

tTEM system

- **Spin-off company**
- **aarhusgeoinstruments.dk**
- **1 employee, based in Aarhus**

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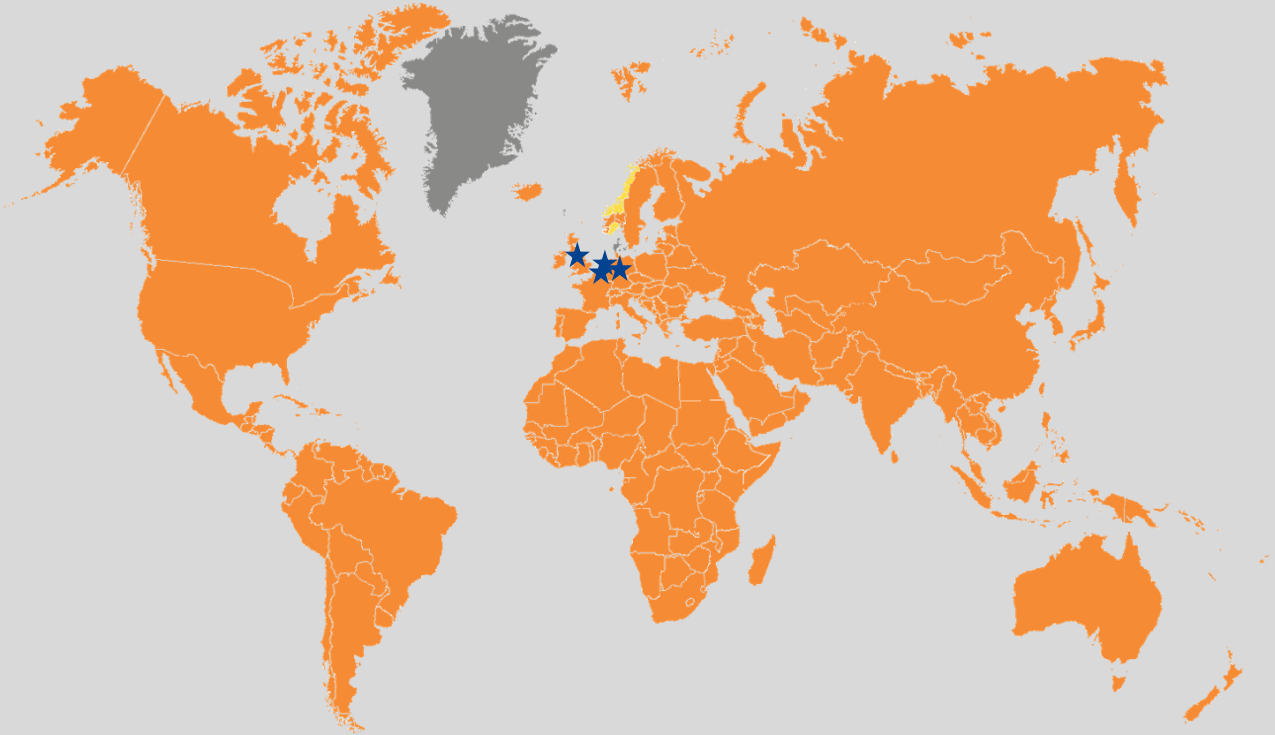
Topsoil extension activities



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Topsoil extension activities

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Topsoil extension activities

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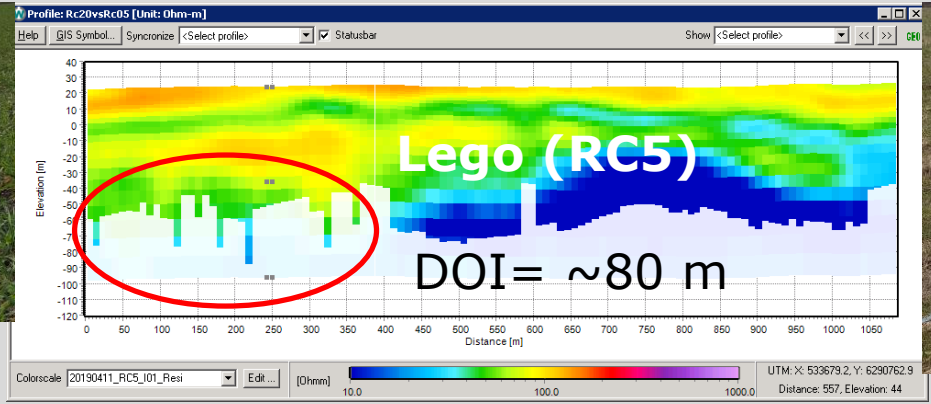
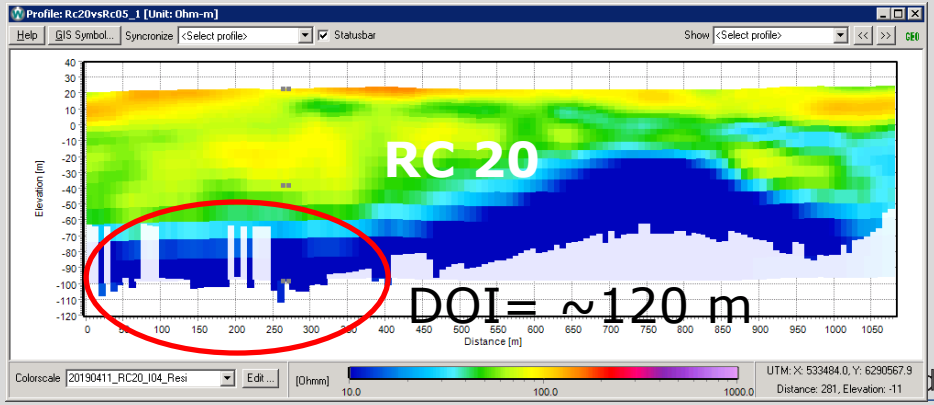
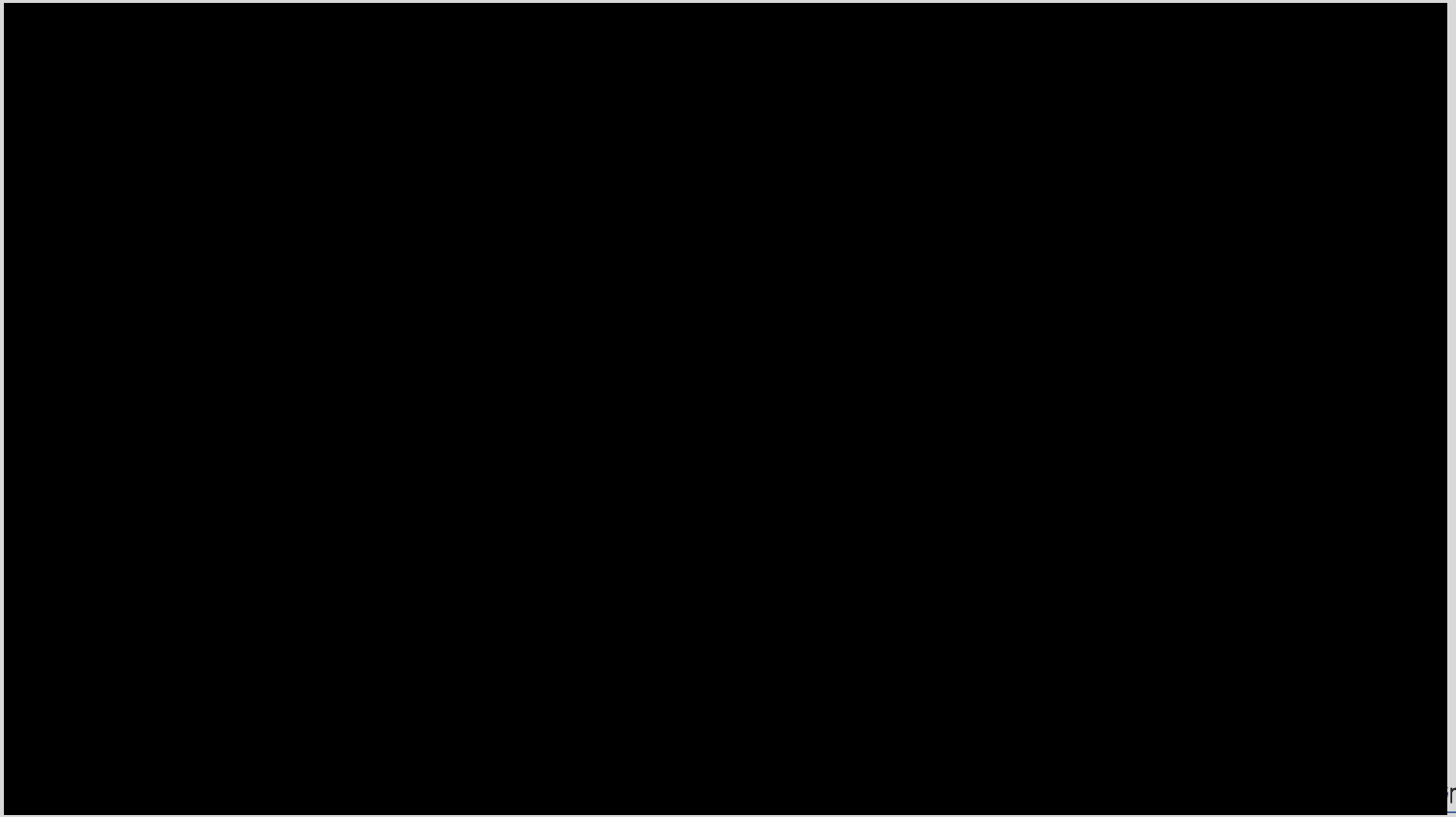
Development – new receiver coil





Development - 3x3 m system

Development – realtime interpretation



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Germany

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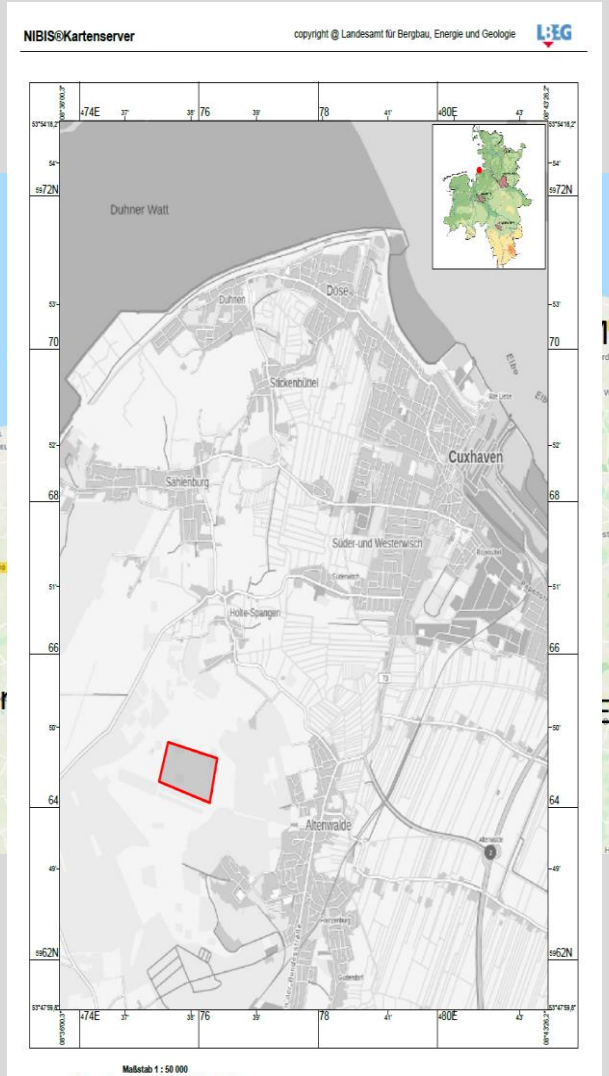
Germany

- *30 ha + forest area*
- *Rewetting moor area*
- *Map impermeable clay layers in 3D and gain a better understanding of the local geology*
- *Nitrate retention – learn from practices in Mapfield project*
- *Map ASAP*

Germany



- *GE2 - 10 ha*
- *Managed aquifer recharge*
- *Improve flow model by getting a better understanding of the geology*
- *Compare with other geophysical methods*
- *Map ASAP*

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Germany – GE-3 Luneplate (GDBF)

Figure 1: Investigation area "Luneplate" Bremerhaven

Figure 2: Chloride-concentration in the aquifer in Bremerhaven. Investigation area with blue border around

- *GE-3 10 ha*
- *Salt-freshwater boundary*
- *Map the boundary in a coastal area with alot of infrastructure and agriculture*

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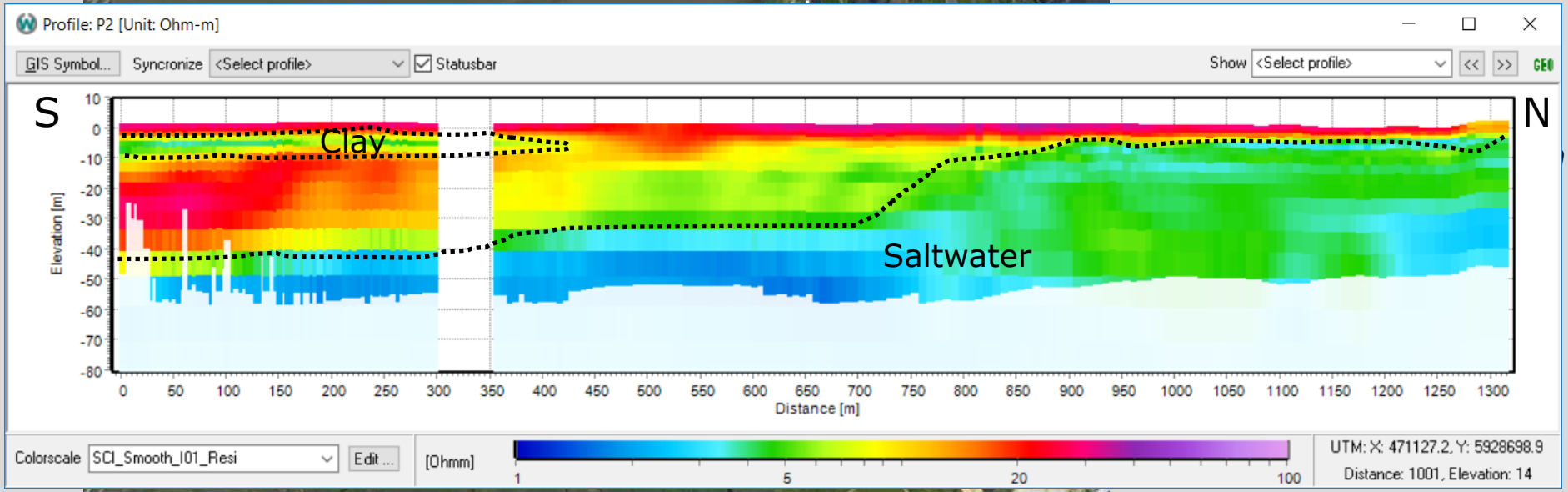

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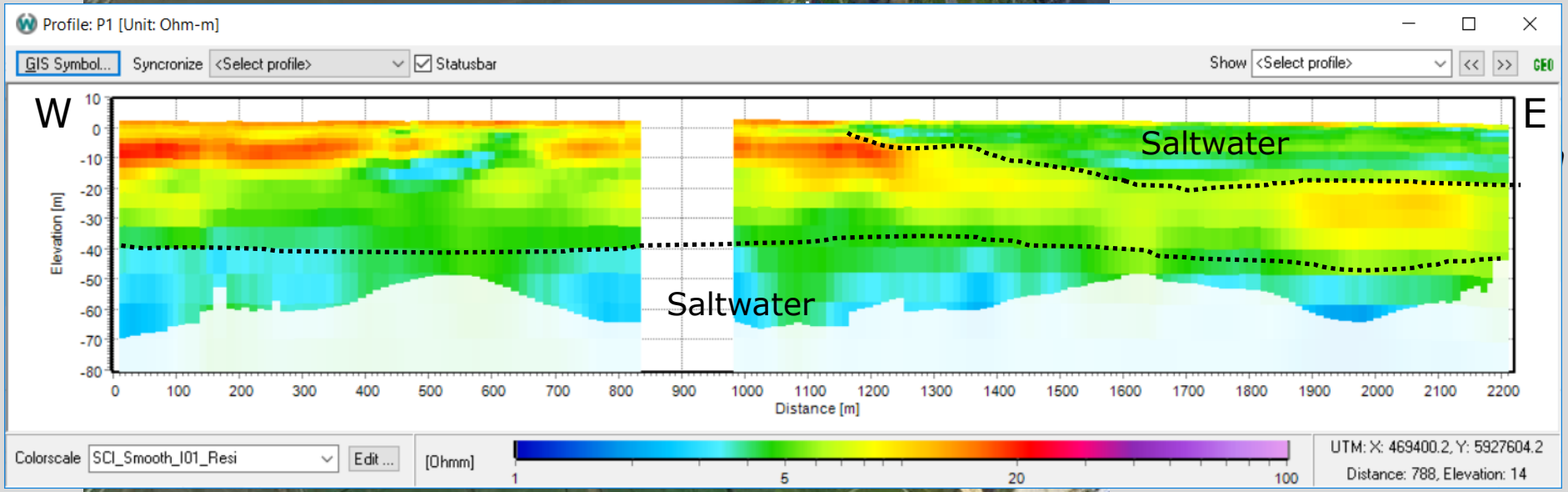

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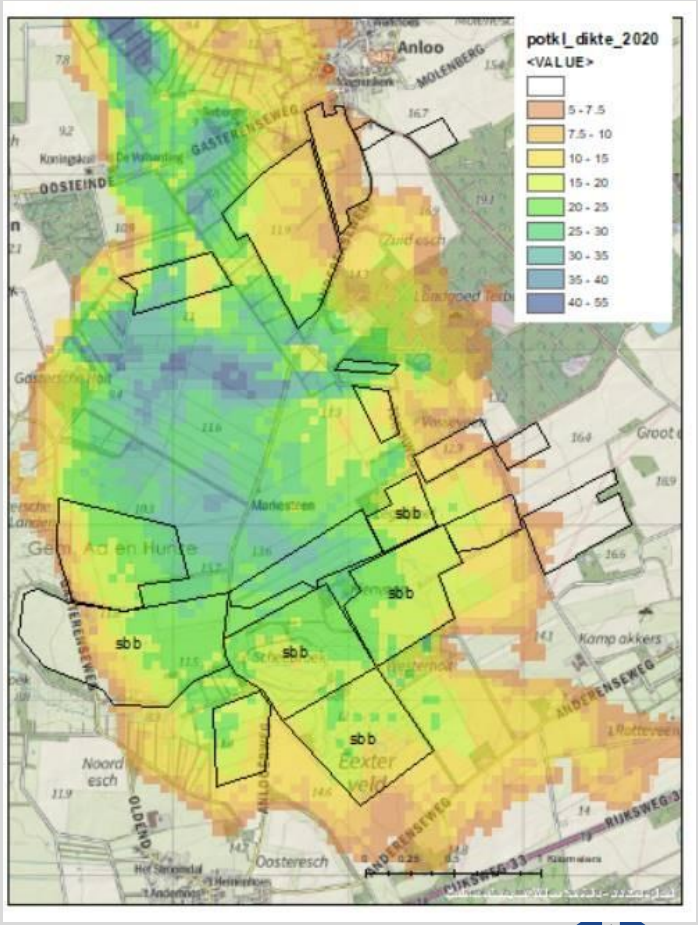
Netherlands

- *Follow-up in the nature2000 Drenthe area – map soil heterogniety, special interest in pot klei.*
- *346 hectares*



TNO innovation for life

provincie Drenthe

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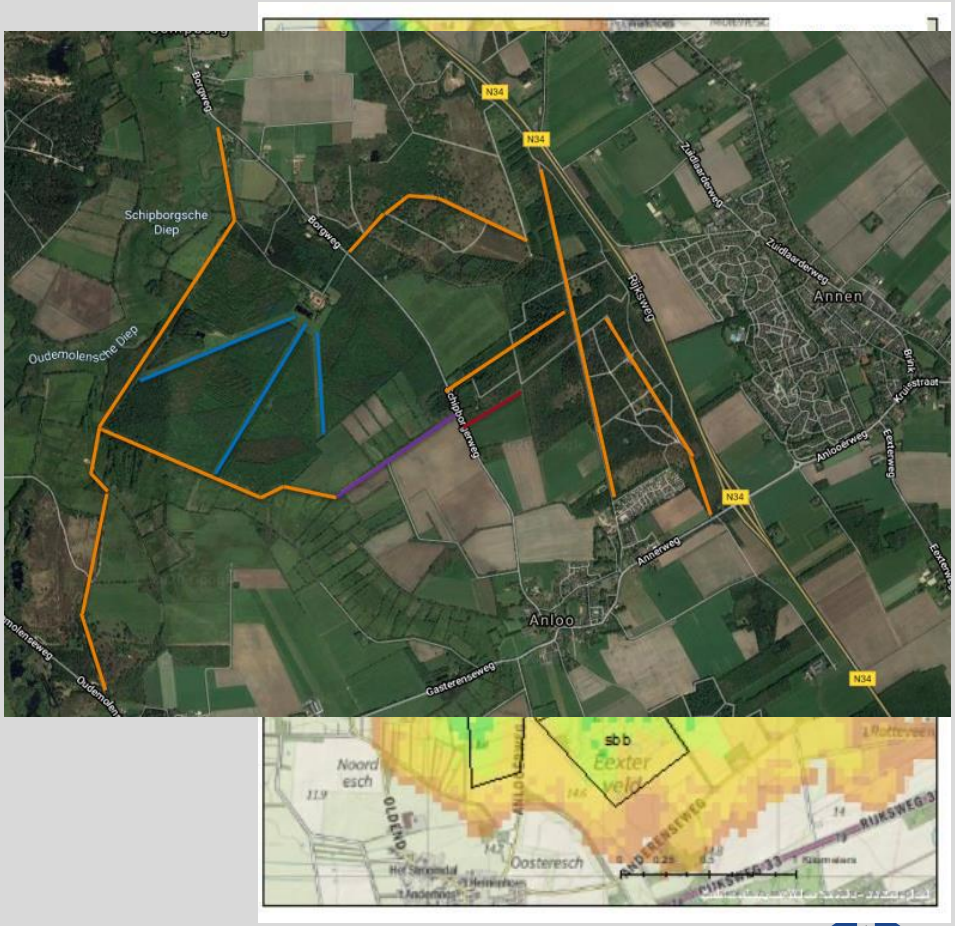
Netherlands

- *Follow-up in the nature2000 Drenthe area – map soil heterogniety, special interest in pot klei.*
- *Mapping the clay filled channel, ca. 12 km*



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- *Follow-up in Drenthe area heterogniety, in pot klei.*
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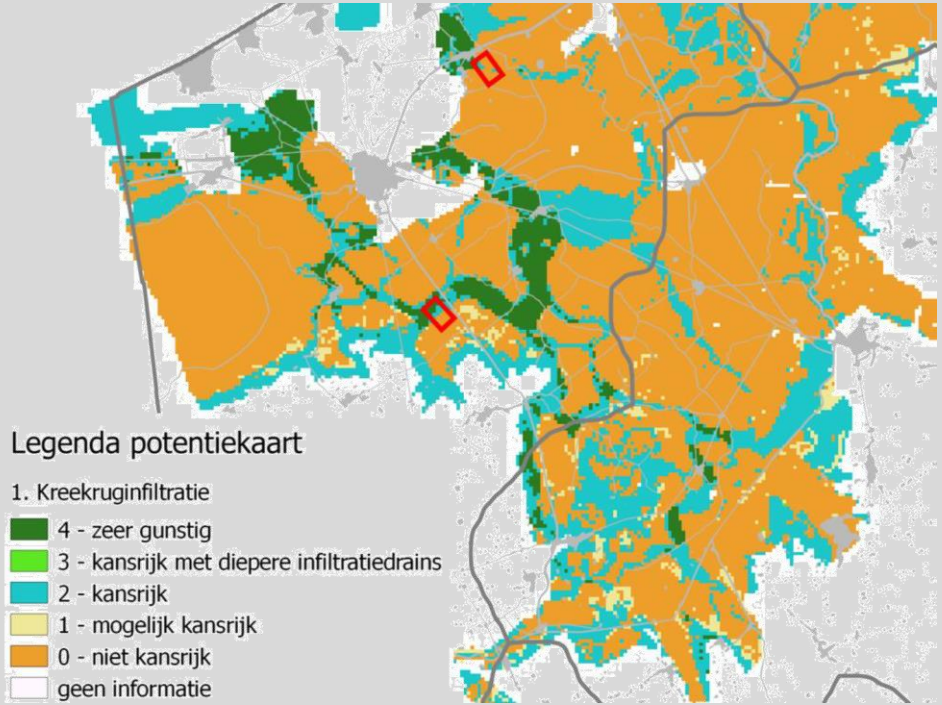
Belgium

- *Creekridge infiltration*
- *Identify saltwater/freshwater boundary in 3D*



Vlaanderen
is milieu

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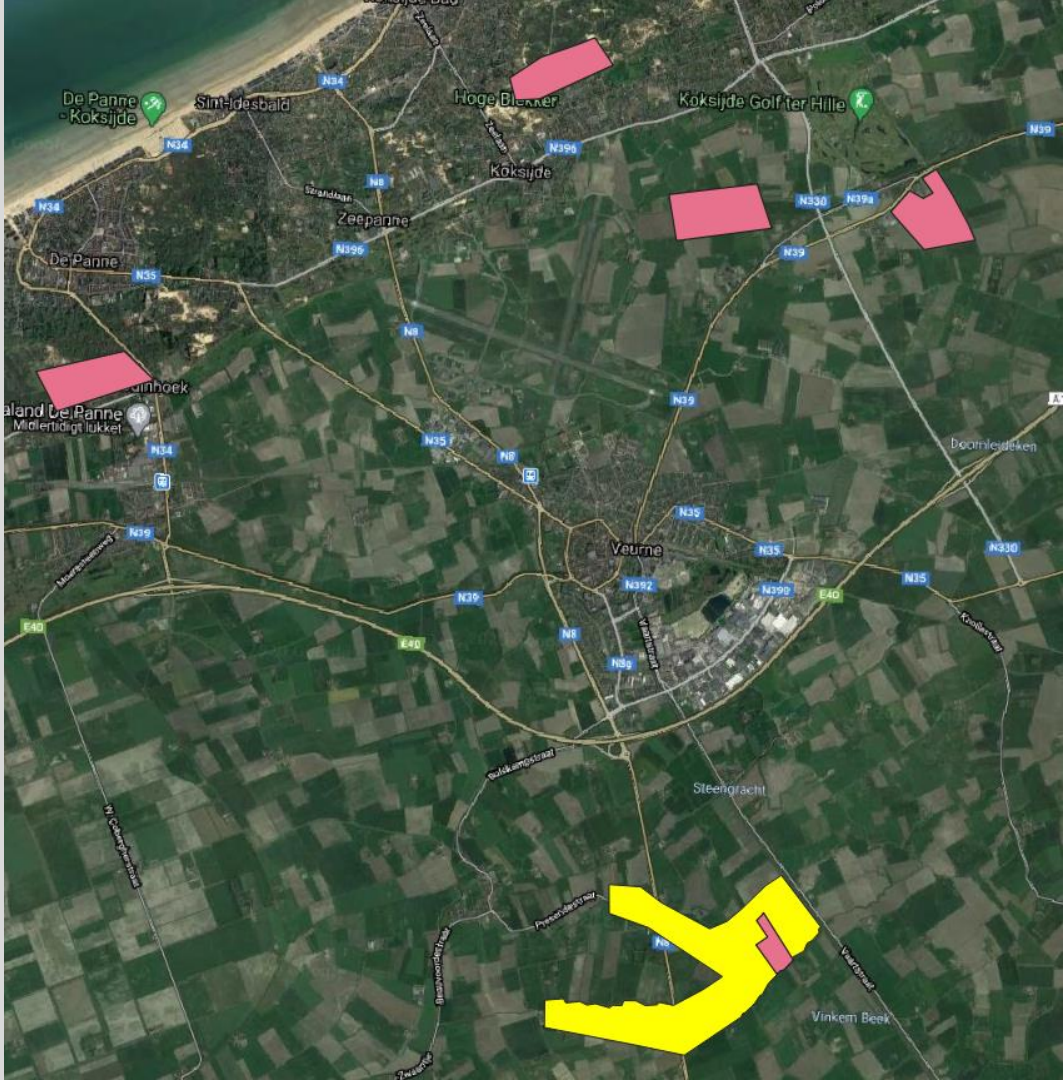
Belgium

- *Creekridge infiltration*
- *Identify saltwater/freshwater boundary in 3D*
- *330 hectares selected*
- *Plan to carry out the work in spring 2020*



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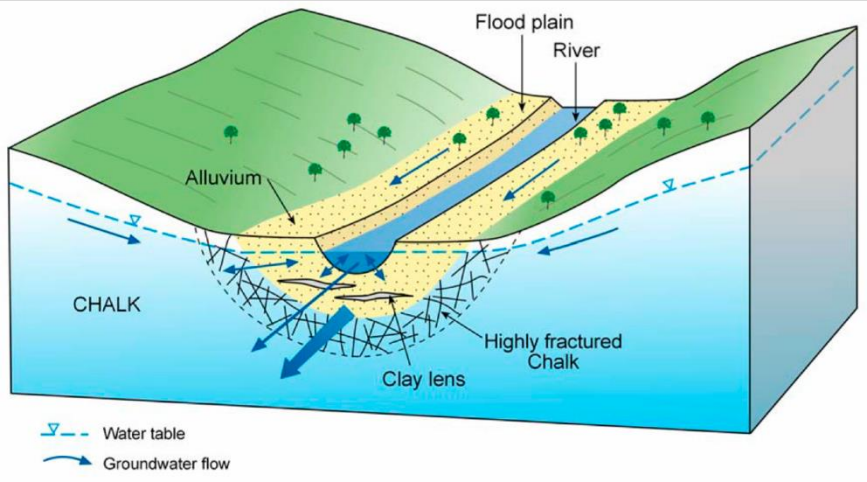
UK

- *Drinking water in fractured chalk*



UK

- *Drinking water in fractured chalk*
  - *Locate hydrologically active fractures (trending SW-NE).*
  - *Ground truth current geological maps.*
  - *Verify level of saline intrusion from north Sea utilising the borehole in town of Cleadon which is known to experience saline waters.*

WEAR Rivers Trust

NORTHUMBRIAN WATER living water

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Abroad - Southafrica, Tanzania, Kenya, Zimbabwe...

- Water exploration. Project with PDJF and local NGO's.

Abroad - New Zealand

- Geothermal zones and nitrate issues.
  Project with GNS and Lincoln Agritech

Abroad – and many more!

- **California**
  - Artificial infiltration
- **Mississippi**
  - River gains and loses
  - FloaTEM and tTEM
- **Sweden**
  - Artificial infiltration, geological mapping, quick clay
- **Switzerland**
  - General geological mapping (water and heat)
- **Greenland**
  - Mapping permafrost and lost engine search


Thanks for the attention