Use of multiple tracers and groundwater flow modelling for the estimation of groundwater travel times to water supply wells, vulnerability assessments and improved management of well fields

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HOVER GeoERA GROUNDWATER

Contents

- Background and example of application
- Applied tracers, dating ranges and vulnerability
- Conducted field work
- Preliminary tracer (^{39}Ar, ^{85}Kr) results
- Simulation of groundwater age distributions (tracer distribution and flow model simulations)
- Recommendations

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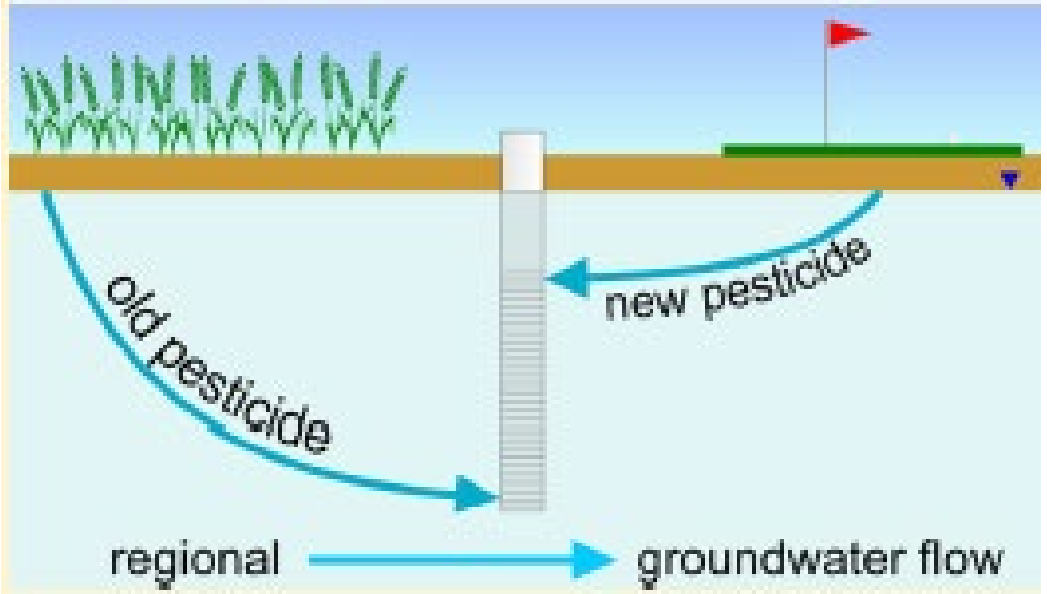
Background

- Pesticide contamination is documented for an increasing number of Danish water supply wells although regulations to avoid this were implemented decades ago –

- what is the source and history of these contaminations and the vulnerability of the wells towards pollution from the surface?



Jakobsen et al 2020. ES&T, 54, 158−165,
DOI: 10.1021/acs.est.9b03996

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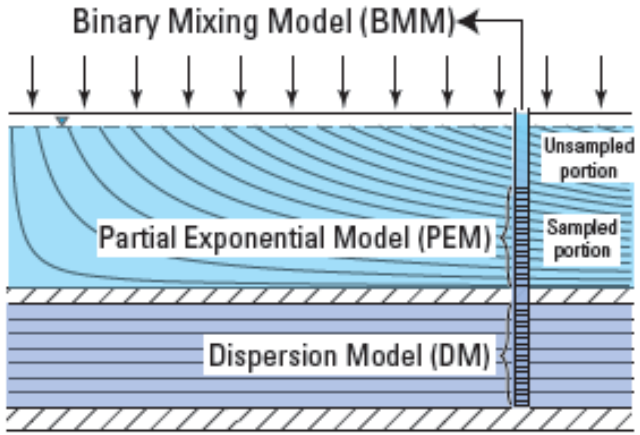
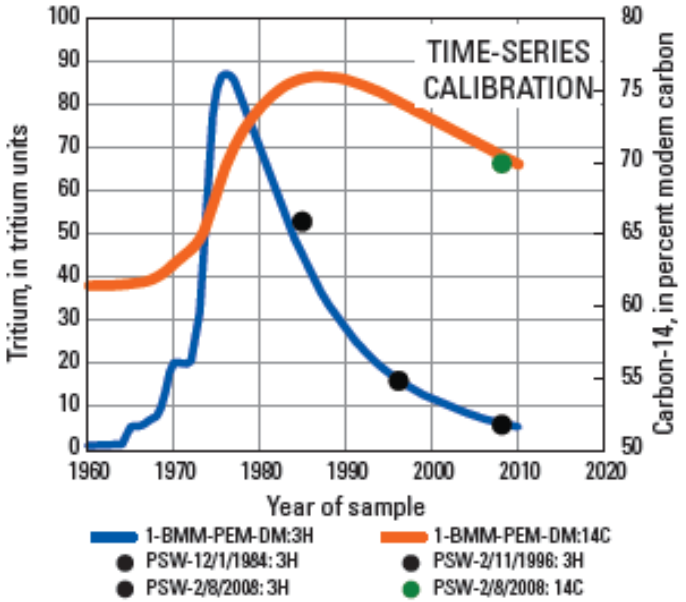
Assessing contamination history and fate by simulating tracer and groundwater age distributions in long-screened wells

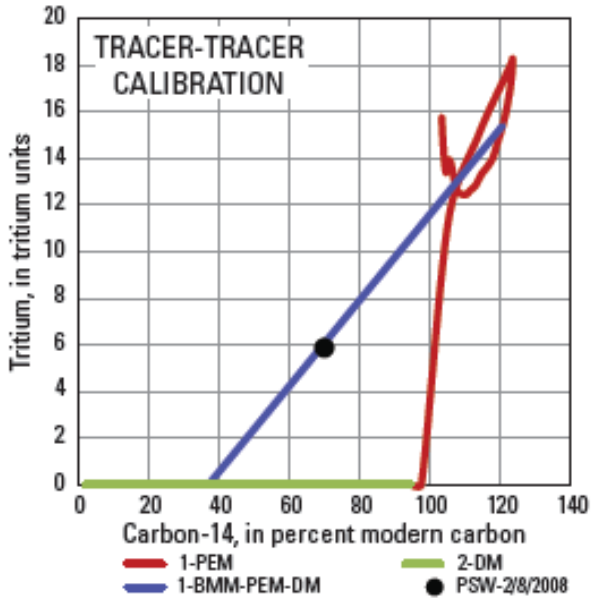
HYDROGEOLOGIC CONCEPTUALIZATION



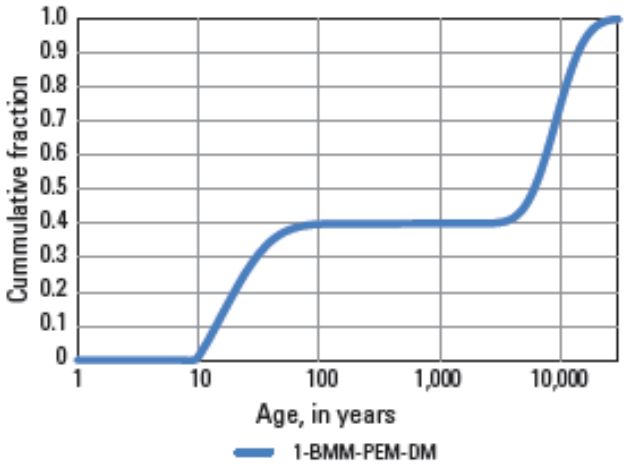
Jurgens et al., USGS, report, 4-F3, 2012.

CALIBRATION TO MEASURED TRACER CONCENTRATIONS

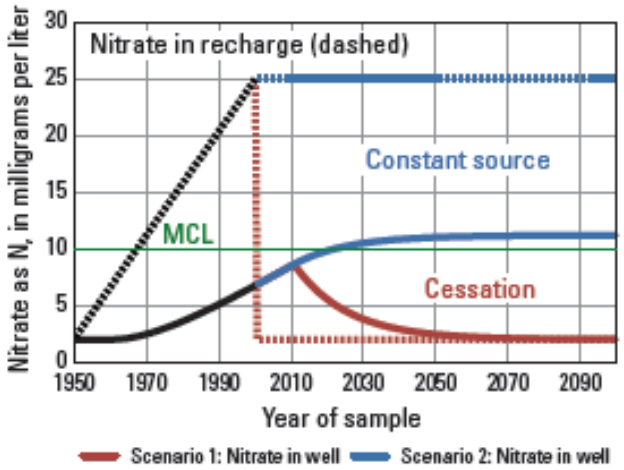




CALIBRATED AGE DISTRIBUTION



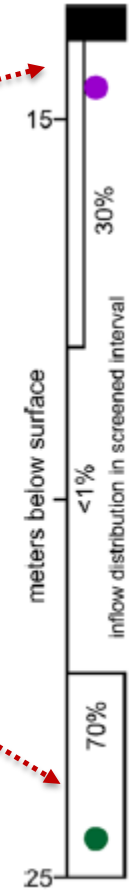
CONTAMINANT FORECASTING



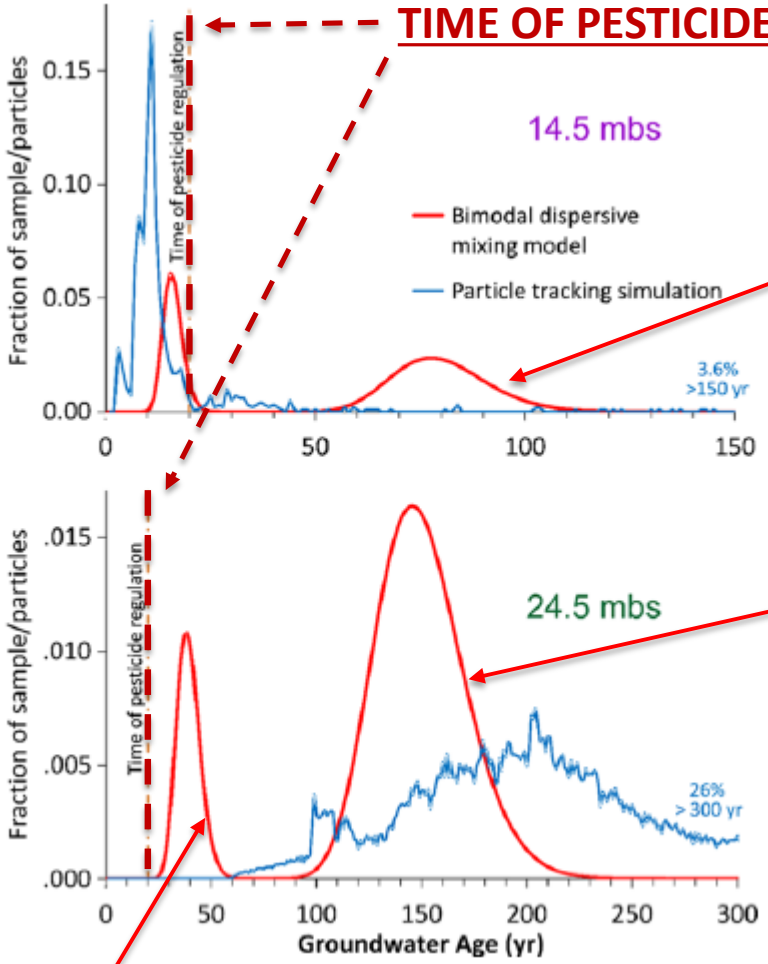
Example of age distributions in top and bottom of water supply well estimated by simulation of tracer distributions and particle tracking

Bentazon contamination

Dichlorprop contamination



TIME OF PESTICIDE REGULATION (1995)



Bimodal groundwater age distribution in top of water supply well (14.5 m below surface) as simulated by TracerLPM

Bimodal groundwater age distribution in bottom of water supply well (24.5 m below surface) as simulated by TracerLPM

Jakobsen et al 2020. ES&T, 54, 158−165, DOI: 10.1021/acs.est.9b03996

Simulated by TracerLPM (Jurgens et al., USGS report, 4-F3)

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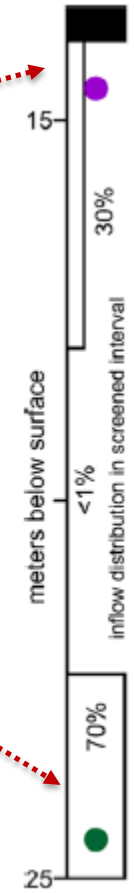
Example of age distributions – fractions of different groundwater age ranges

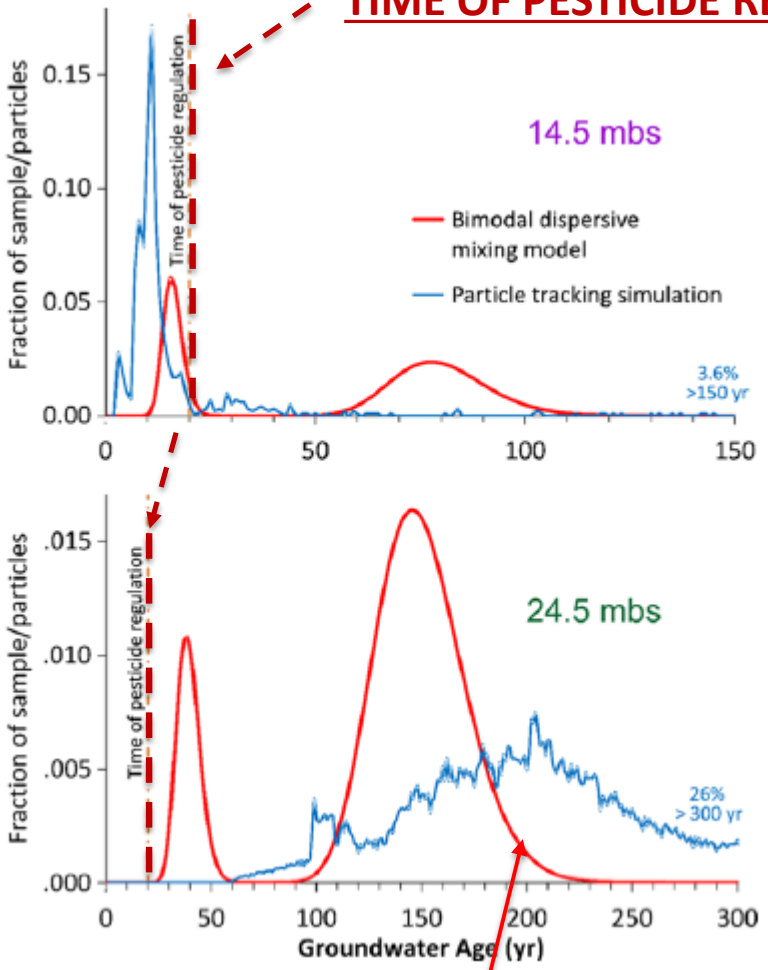
Bentazon contamination

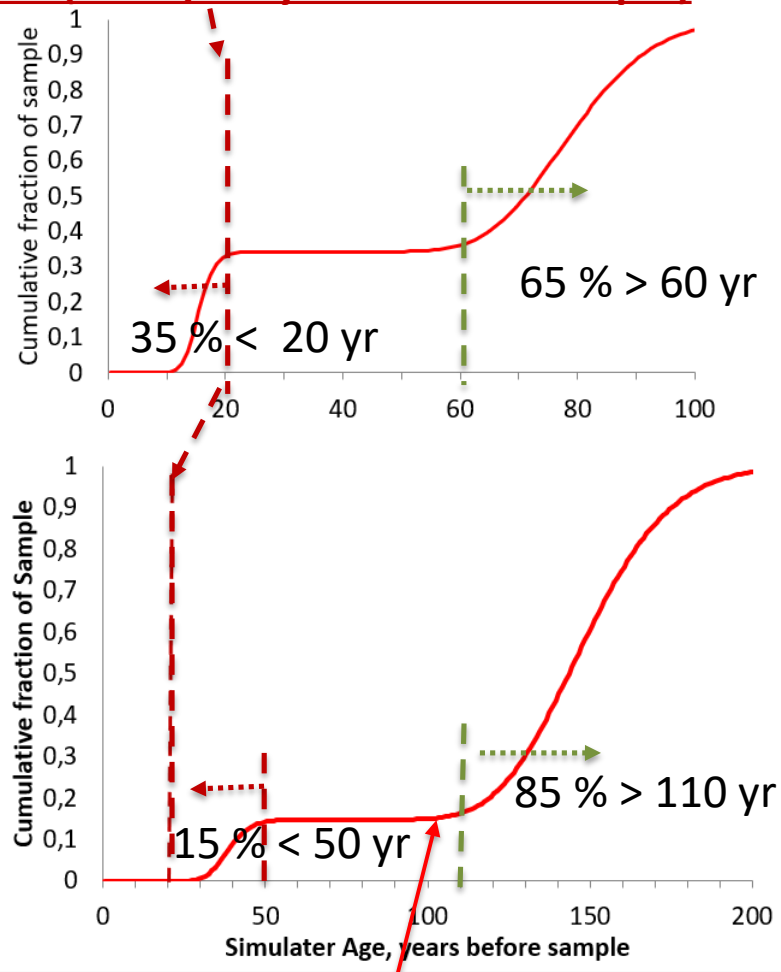
Dichlorprop contamination



Jakobsen et al 2020.
ES&T, 54, 158−165,

TIME OF PESTICIDE REGULATION (1995 / 20 years before sample)





Simulated by TracerLPM (Jurgens et al., USGS report, 4-F3)

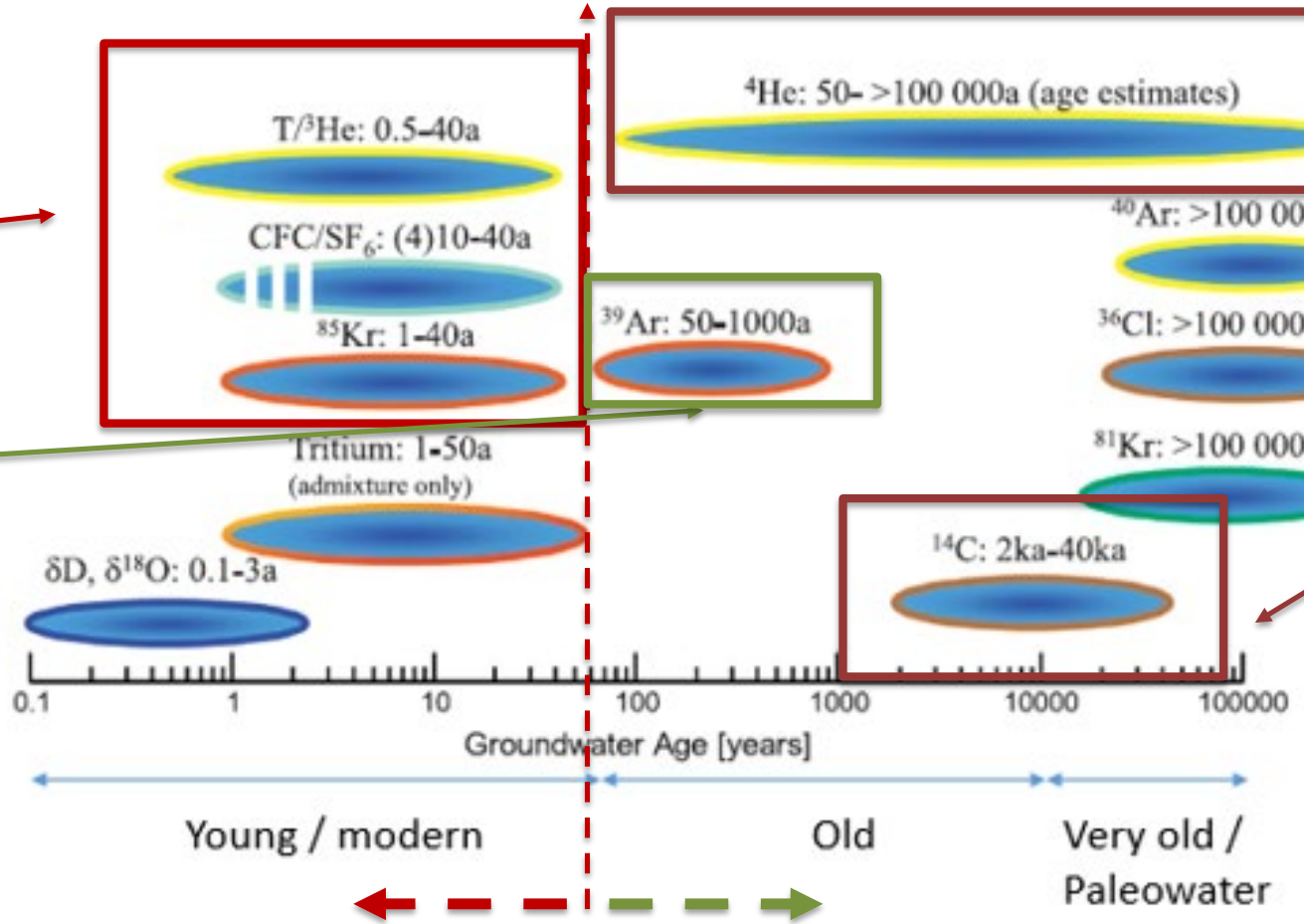
Tracers used in this study to estimate age ranges,

age ranges and vulnerability

Tracers for dating of young groundwater

Tracers for dating of old groundwater

Tracers for dating of paleowater



Modified from Suckow, 2014. Appl. Geochem, 50, 222-230.

Vulnerability to pollution from surface: High / at risk **Low / no to little risk**

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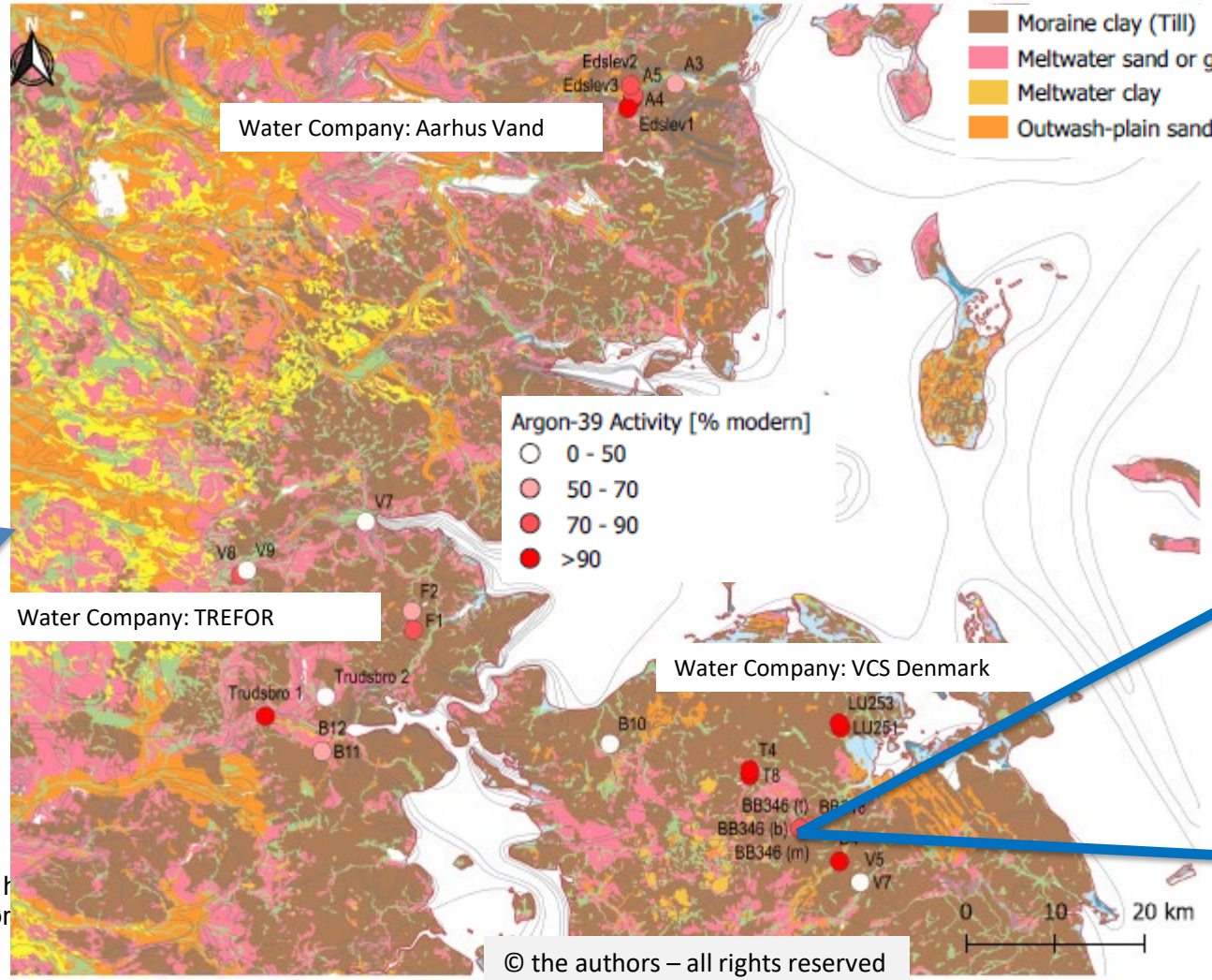
HOVER WP6 field work and preparations for collection of groundwater samples for the analysis of dating tracers and emerging contaminants (WP8)

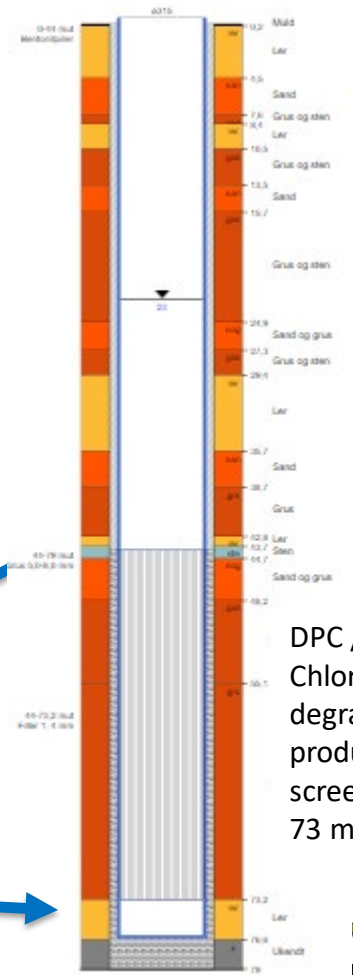
Three groundwater sampling campaigns were succesfully completed in Denmark during summer 2019 together with Univ. Bern, Univ. Heidelberg, Univ. Bremen, TNO, and three major Danish water companies. This work was made possible through additional funding for GeoERA from Innovation Fund Denmark.

A similar sampling campaign was conducted (February, 2020) by TNO in collaboration with Univ. Heidelberg.

Some tracers but not all have been analysed at this point in time – here we show some preliminary results from Denmark

30 water supply wells of three major water supply companies in DK sampled during summer 2019 – ^{39}Ar data





DPC / Chloridazon degradation product in screen from 44-73 mbs

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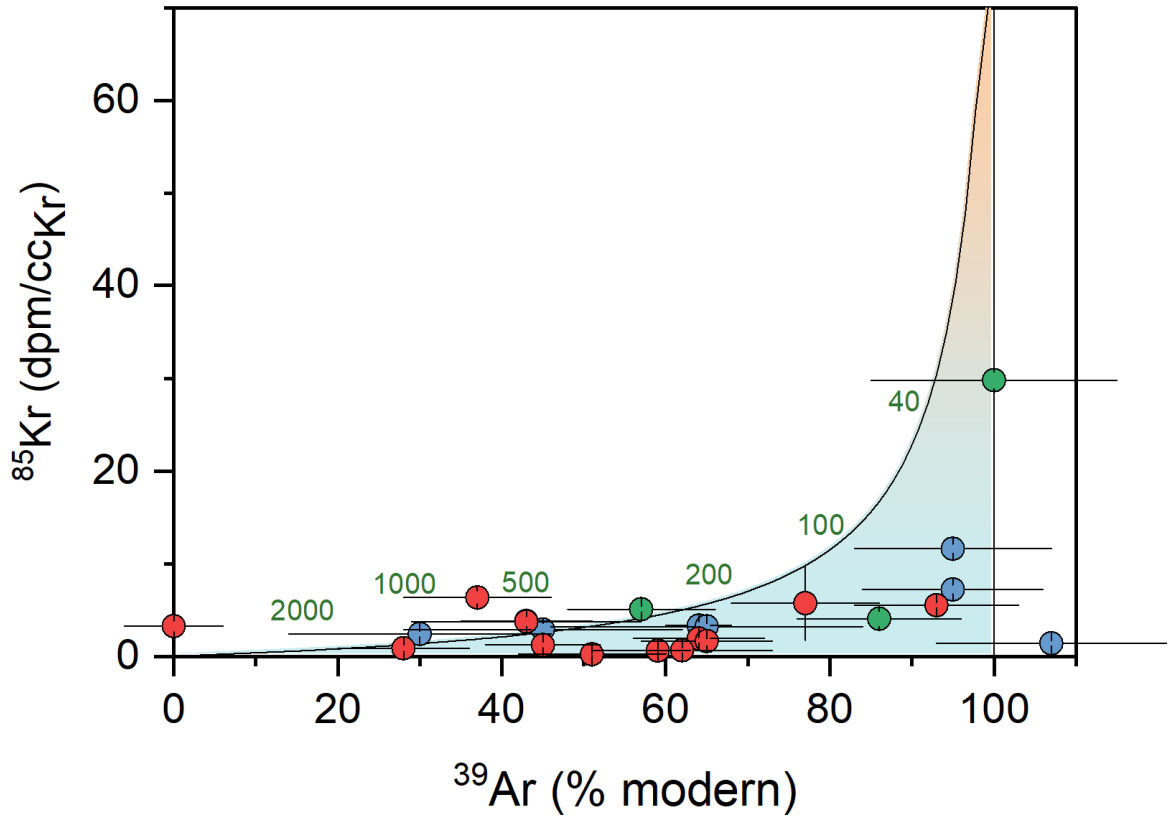
^{85}Kr vs ^{39}Ar activity –

incl. simulated ages assuming exponential flow – preliminary result



$t_{1/2,\ ^{39}Ar}$ = 269 yr

$t_{1/2,\ ^{85}Kr}$ = 10.8 yr

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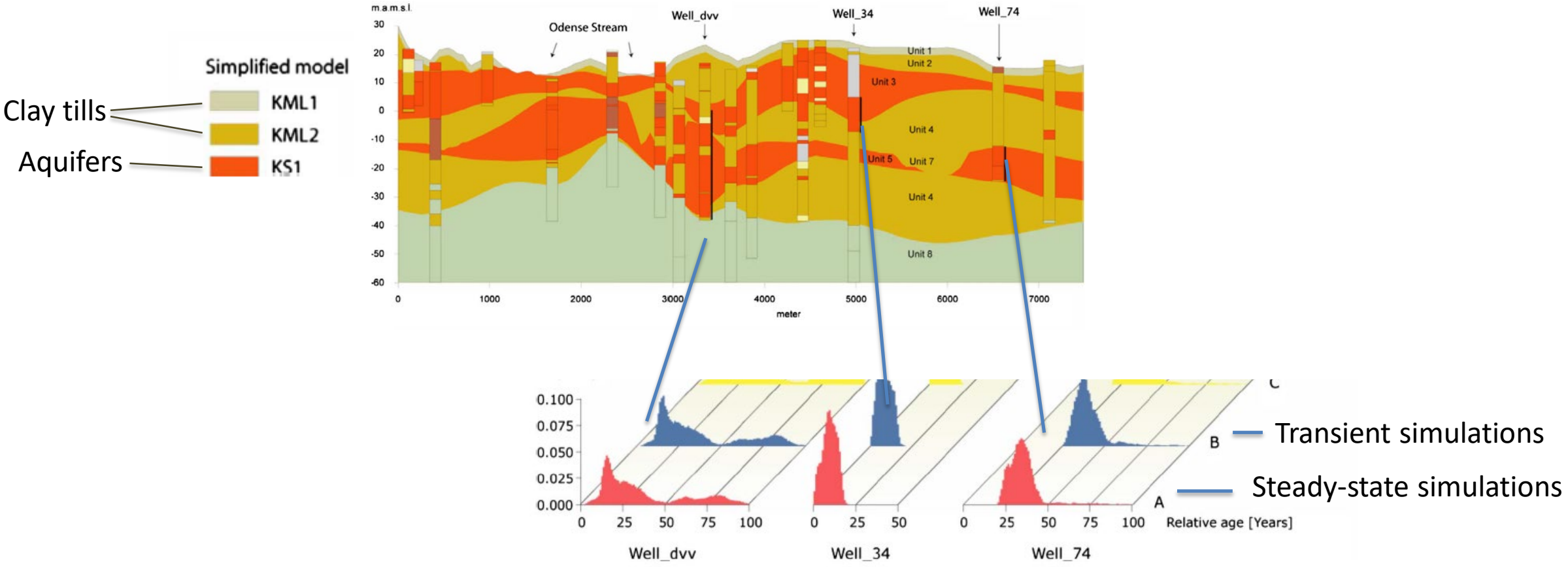
Simulation of groundwater age distributions by flow model – example from one of the investigated well fields on the Island of Funen



Troldborg et al., 2008. J. Hydrol. Eng. ASCE, 1037-1048.

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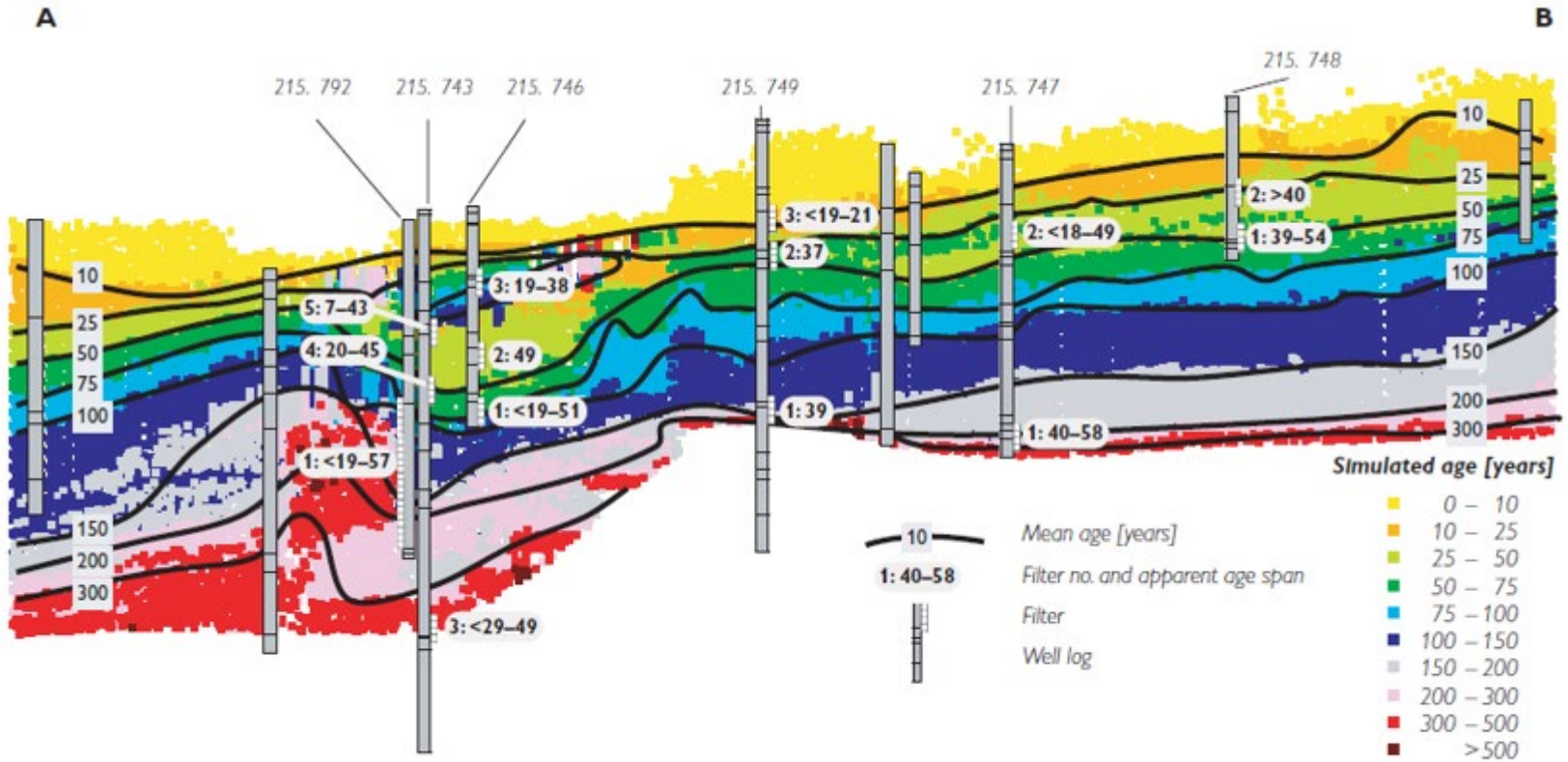
Example of groundwater age distribution simulated by particle tracking



Troldborg et al., 2007, Hydrogeo. J. , 15, 843 -860.

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Recommendations

The use of multiple-tracers is recommended as they provide options for identifying mixtures of young and old groundwater and estimating fractions of each

Combined use of tracer analyses and particle tracking, solute transport or other groundwater flow modelling concepts for simulation of travel time distributions is recommended as the methods either corroborate each other or provide valuable information for improved system understanding and the validity of applied models.

The application of tracers may provide information on e.g. short-circuiting and fast contaminant transport due to geological variation or poorly developed wells (poor bentonite seals, holes in casings etc.) at local scale, which is not possible to obtain by models with a relatively large resolution

The application of particle tracking and groundwater flow models on the other hand, may identify contaminant source areas - an information, which typically cannot be obtained from tracers only, and in addition visualize regional groundwater age distributions.

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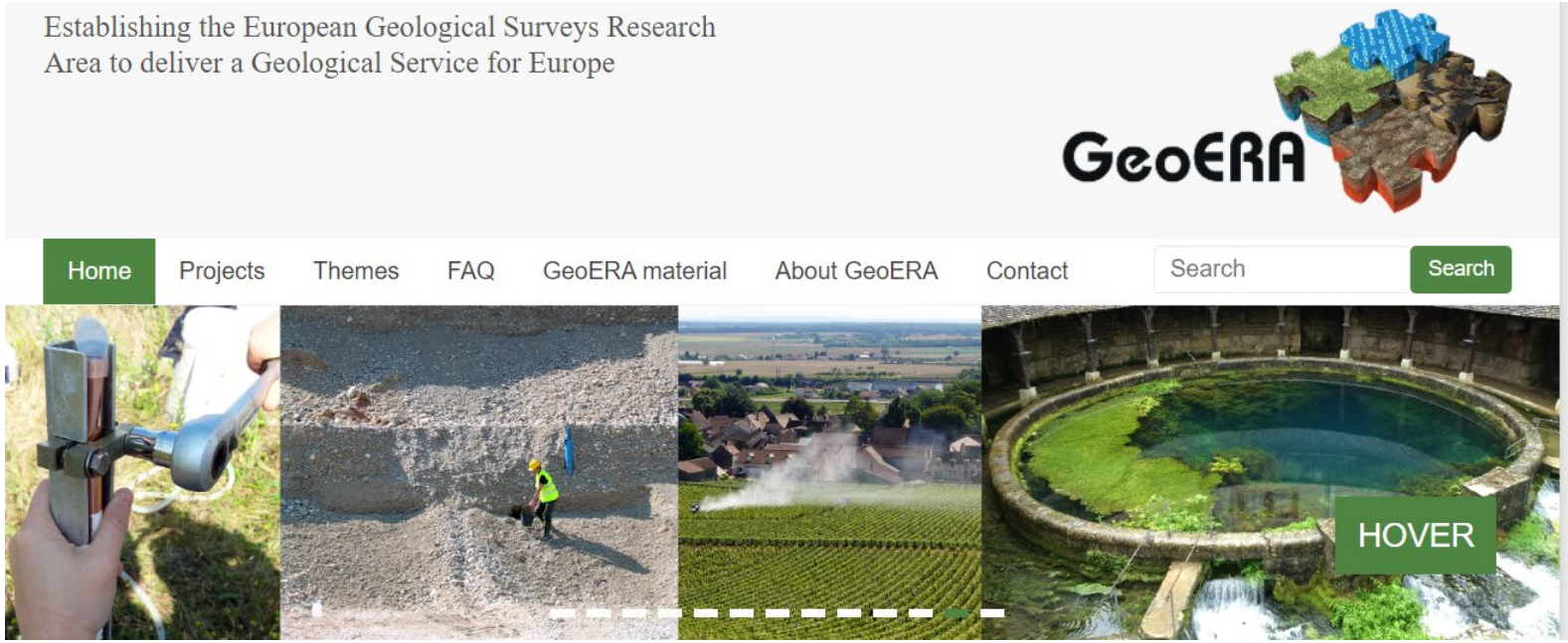
Thank you for your attention ☺

Visit the HOVER website, the newsletter of the HOVER project and the other GeoERA groundwater project websites at: www.geoera.eu.



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