9 June 2026, Manchester

Erika Neeft

Measurements from
TNO: Hoving, Kivits and Griffioen
UU : Ma and Behrends
TU-Delft: Meijvogel-de Koning and Dieudonné

Transport and storage clay cores: Ruud Lauer

A Dutch natural analogue for disposal of depleted uranium

CONTENT

- Depleted uranium
- Usual analogues
- Uranium in the Netherlands
- Preliminary conclusions

DEPLETED URANIUM

	Natural uranium	Depleted uranium
^{234}U	0.0055	0.01
^{235}U	0.72	0.36
^{236}U	-	0.14
^{238}U	99.27	99.49

Karlsruher Nucklidkarte

From activity concentration in OPERA-PU-COV023

DEPLETED URANIUM

	Natural uranium	Depleted uranium
Uraninite (pitchblende)	UO_2	U_3O_8
brannerite	U-Ti-oxide	
davidite	U-Fe-Ti-oxide	
coiffinite	U-silicate	

USUAL ANALOGUES ARE URANIUM MINES

Table 1.11. **Inferred recoverable resources by deposit type**

(as of 1 January 2023, tonnes U, rounded to nearest 100 tonnes†)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Proterozoic unconformity	0	9 700	127 800	214 300
Sandstone	268 400	519 400	799 100	1 067 800
Polymetallic Fe-Oxide Breccia Complex	0	0	353 100	422 100
Paleo-quartz-pebble conglomerate[(a)]	5 500	67 200	79 900	108 900
Granite-related	0	17 900	42 400	60 800
Metamorphite	28 300	28 300	30 900	37 400
Intrusive	0	0	120 700	310 400
Volcanic-related	0	26 400	95 600	117 600
Metasomatite	0	30 300	315 200	457 700
Surficial deposits	0	1 100	59 800	166 400
Carbonate	0	0	19 800	19 800
Collapse breccia	0	0	0	0
Phosphate	0	0	7 100	45 900
Lignite - coal	0	0	1 900	72 700
Black shale	0	0	0	15 200
Unspecified	0	0	3 600	38 700
Total	**302 200**	**700 400**	**2 056 900**	**3 155 700**

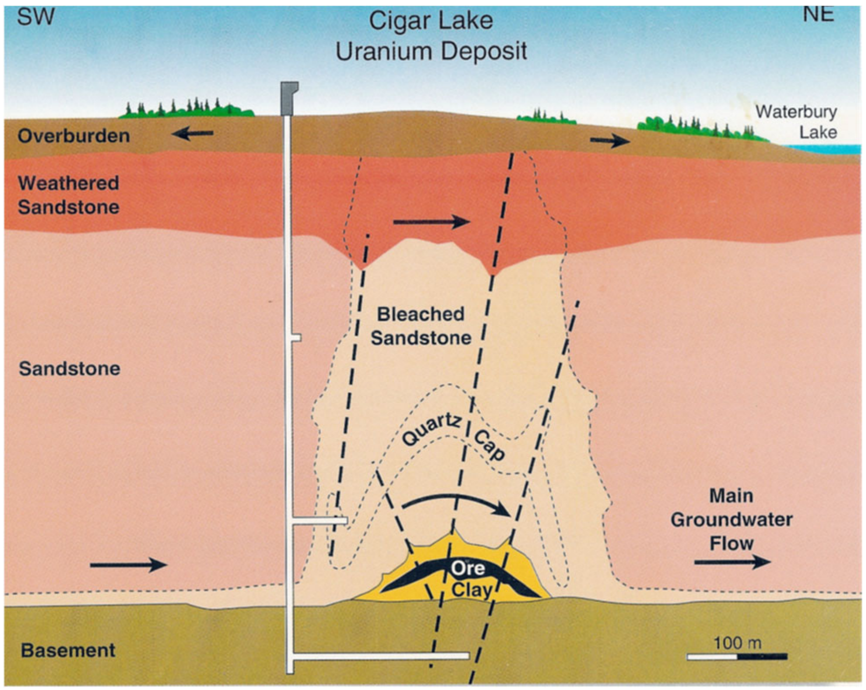
† Totals may not sum exactly, or exactly match totals reported in other tables of this report, due to rounding.

(a) In South Africa, Paleo-quartz-pebble conglomerate resources include tailings resources.

Redbook IAEA & NEA

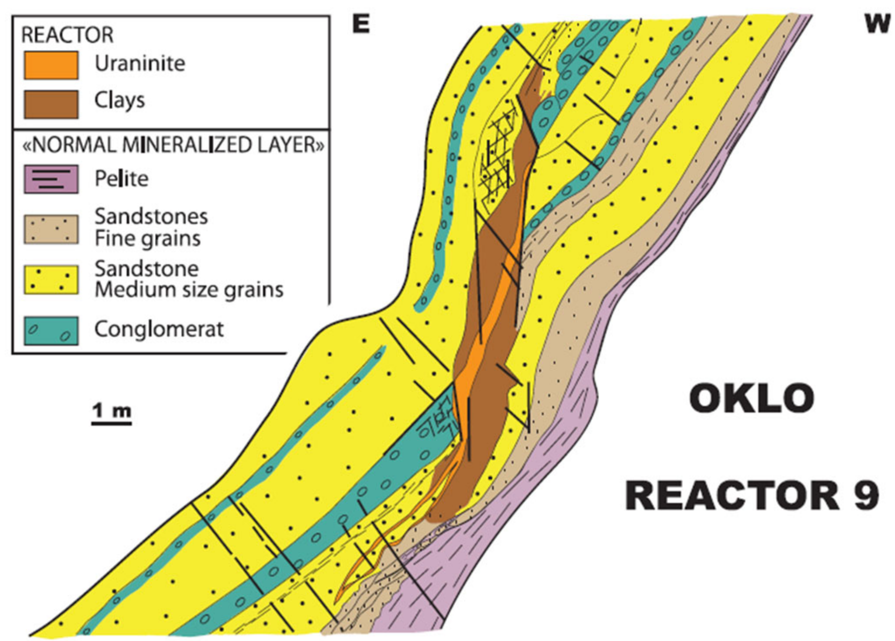
URANIUM MINES

Characterised in red book as Proterozoic unconformity



NaNet
From Cramer & Smellie

U deposit characterised in red book as Sandstone



Many studies e.g. by IAEA since 1975
and others e.g. Bentridi et al., 2011

URANIUM IN CLAYS

BLACK SHALE IN RED BOOK

Paleogene Clays
23 Ma-66 Ma
e.g. Ypresian 56 Ma to 48 Ma

Organic matter
-

Clay minerals
3 mg/g

Hoving et al., 2024&2025
https://doi.org/10.1144/gslspecpub2025-25

Callovo-Oxfordian
166 Ma to 157 Ma

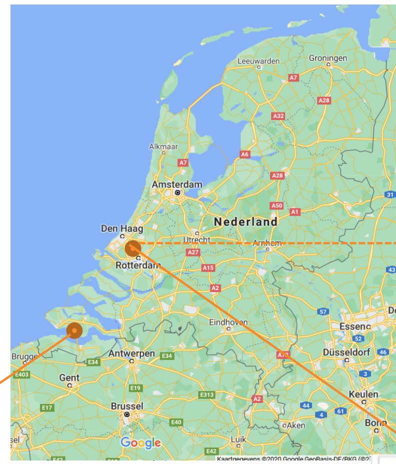
Organic matter
0.069 mg/kg

Clay minerals
2.5 mg/kg

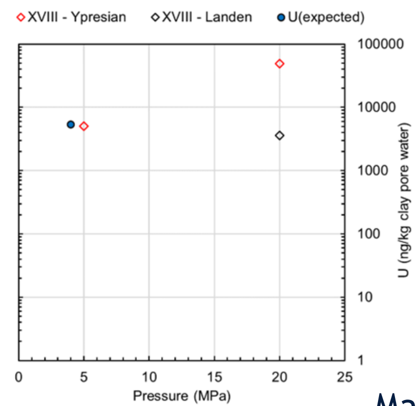
Phosphate nodules
32 mg/kg

Montavon et al. 2022

URANIUM IN THE NETHERLANDS

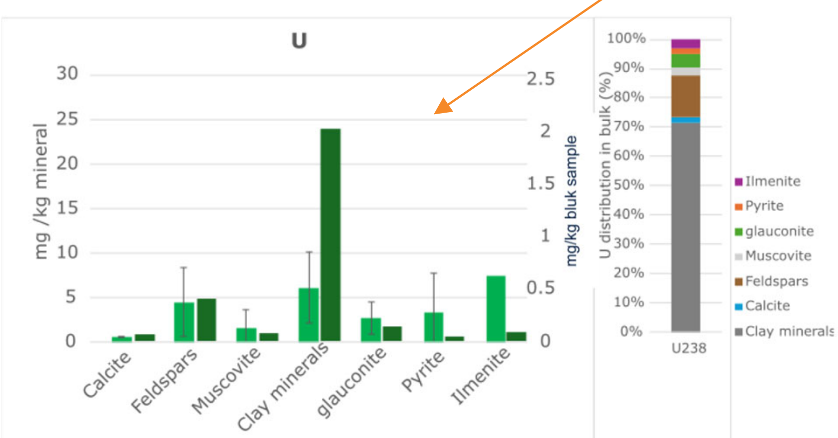


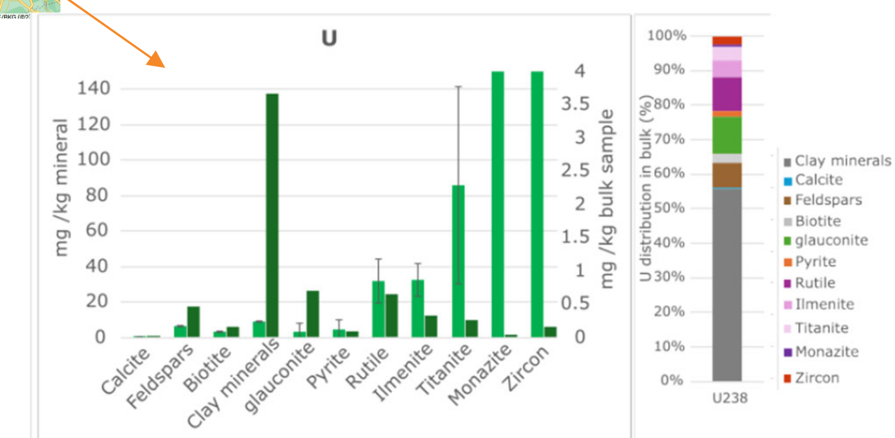
liquid



Data from
Ma & Behrends, 2026

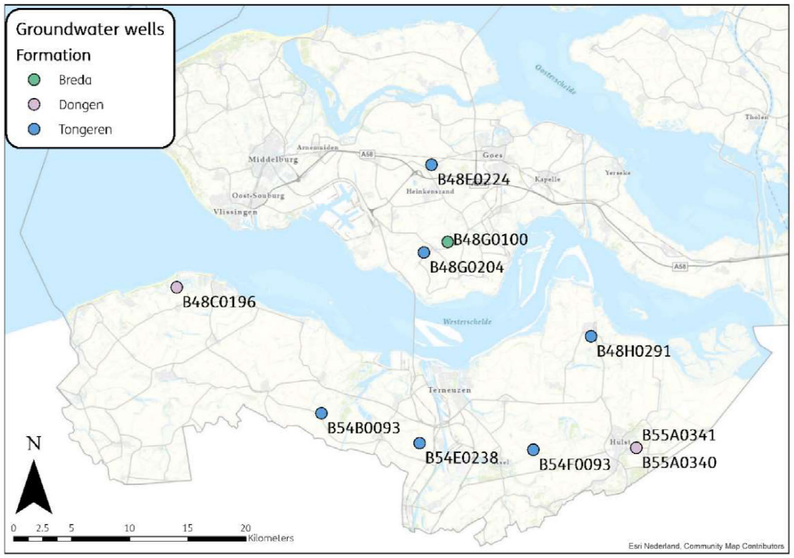
solids



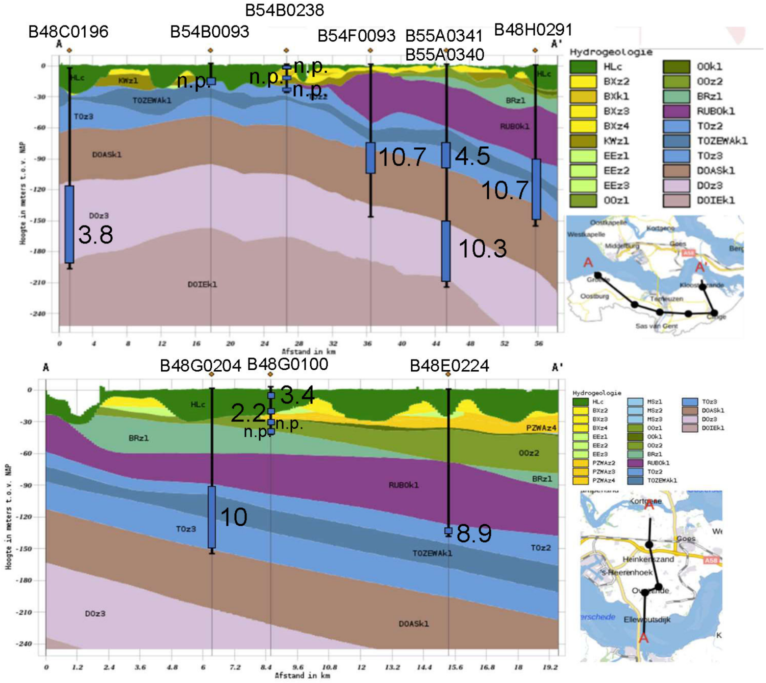


Hoving et al., 2024&2025&(2026 Addendum 20024 report)

URANIUM IN THE NETHERLANDS



Radon in Bq/l



^{238}U maximum 0.67 µg/l
^{238}U maximum 0.008 Bq/l

n.p.= not popssible:
due to excessive gas formation in samples with high EC and chloride concentration

Data from Hoving, A., T. Kivits, and J. Griffioen. TNO 2024 R12632

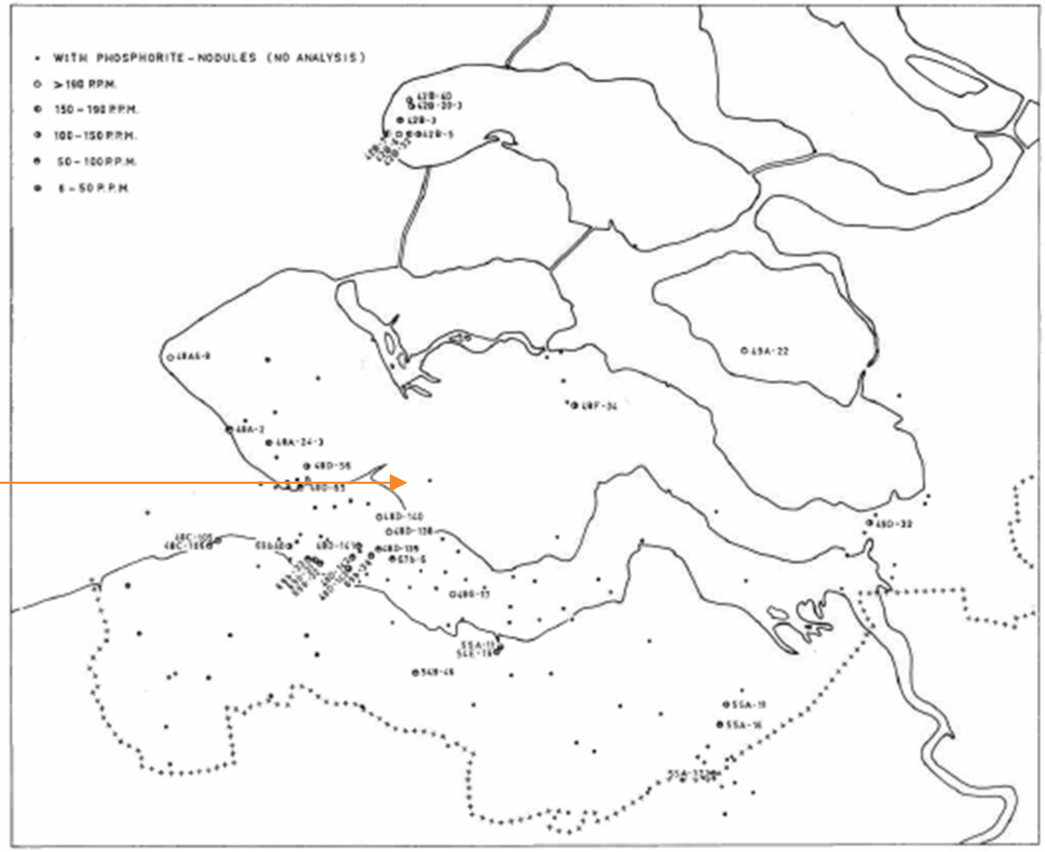
URANIUM IN NETHERLANDS

U deposit in red book phospate

Phophorite nodules in glauconitic sands

Phophorite nodules 24 to 50 m

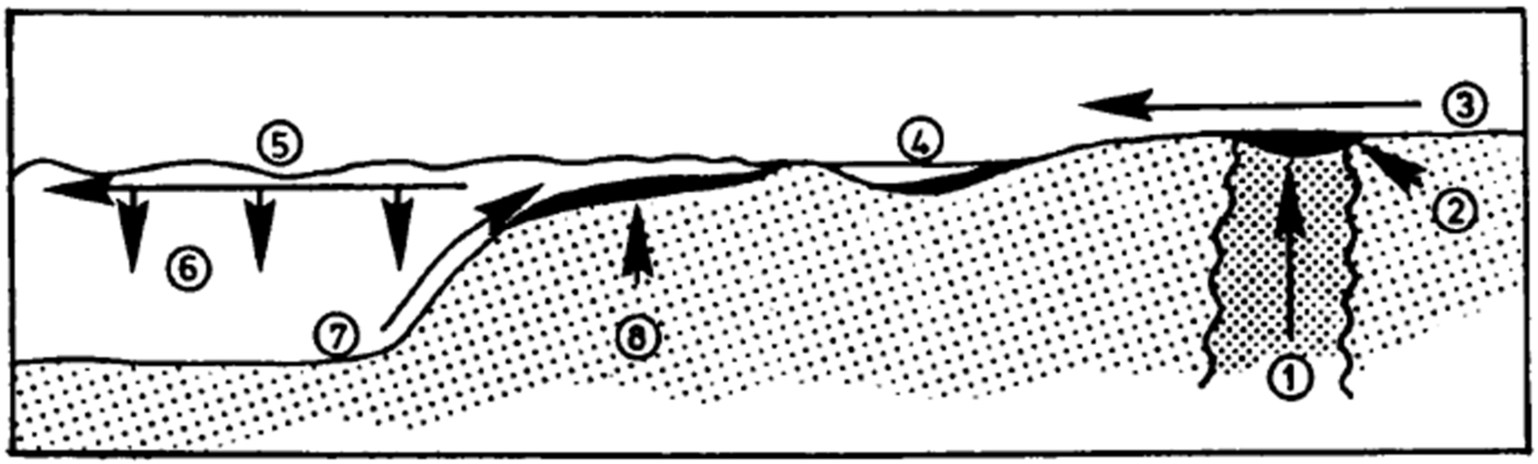
glauconitic sands



Harseveldt, 1973

Drilling
2011
Up to 200 m

PHOSPHATE NODULES



5) & 6) Biological uptake of phosphate

7) Upwelling of phosphate-rich water from deep sea

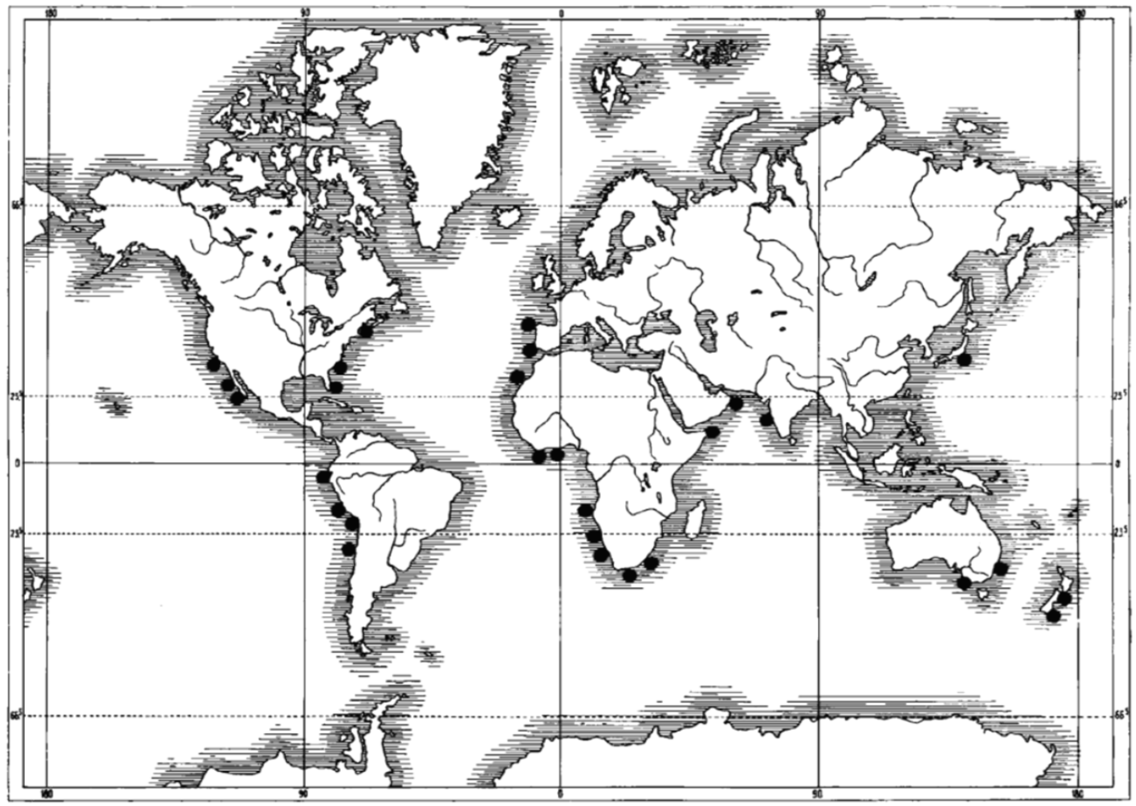
8) Deposit near coastal area

4) Deposit in coastal area (lagune)

1) Intruding igneous rocks
2) Presence of apatite ($Ca_3(PO_4)_3(OH,F)$
3) Phosphate egress by erosion through and groundwater

Laban, 1988 from Sheldon, 1982

PHOSPHATE NODULES



From Holocene to Cretaceous

Laban, 1988 from Sheldon, 1982

PHOSPHATE NODULES

Eastern part of the Netherlands
Rounded by transport
3-5 cm

Laban, 1988

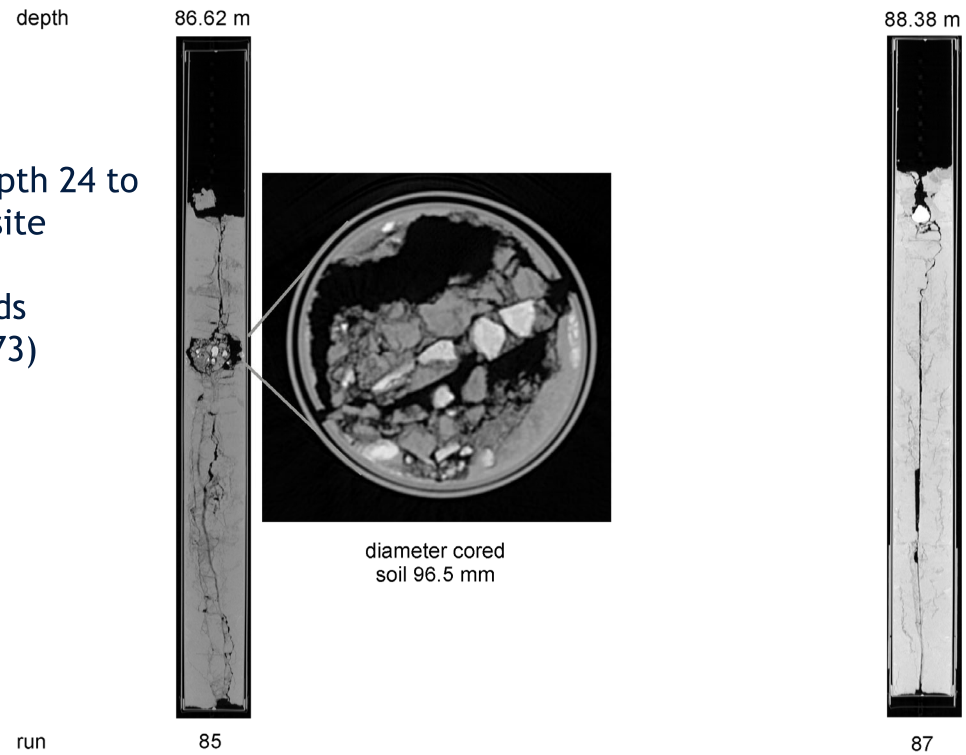
URANIUM IN NETHERLANDS:DRILLING 2011

URANIUM IN NETHERLANDS:DRILLING 2011

Phophorite nodules depth 24 to 50 m at drilling site

glauconitic sands (Harseveldt, 1973)

2011
Also at
higher depths

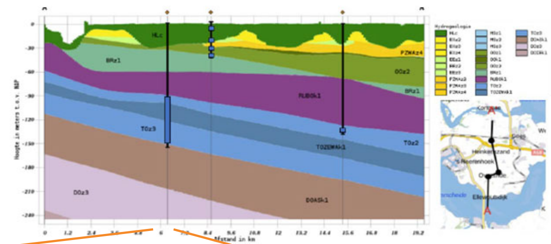


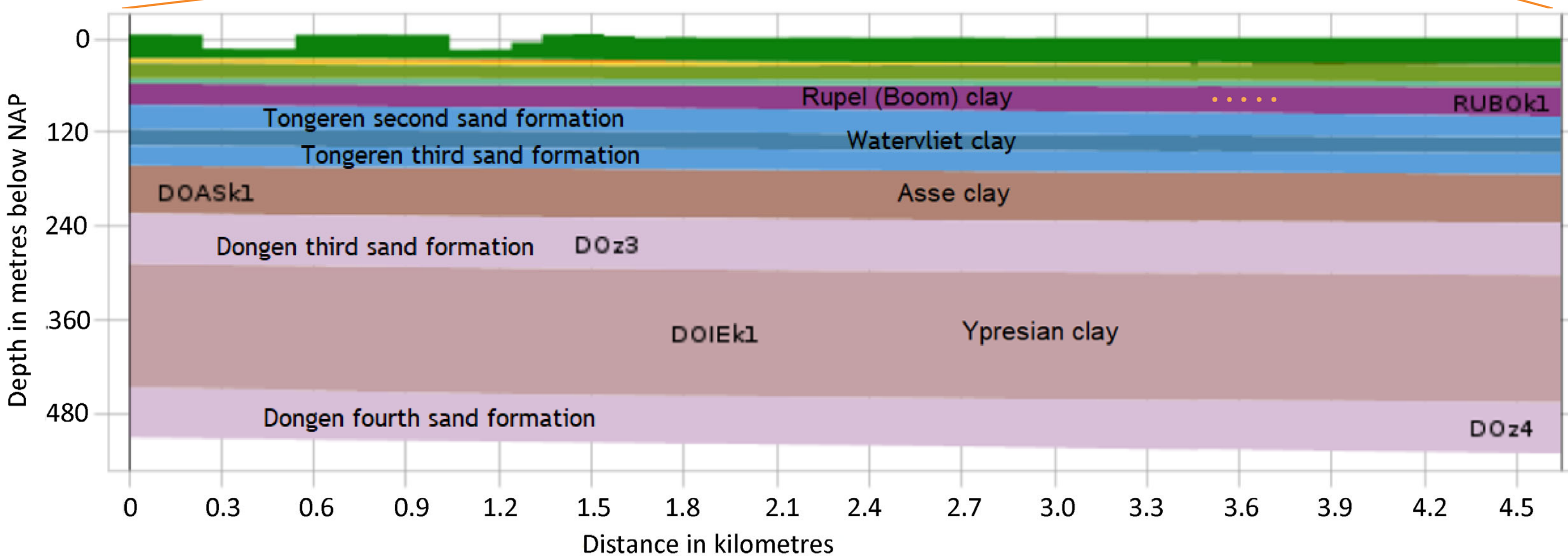
Breda sand,
Paleogene (Ruisbroek) sand
and ..

Preliminary ground investigations report - project KCB2 Borssele, the Netherlands
DOI: https://doi.org/10.4121/747dafc5-9686-437a-9c93-09d7d873fc72
Dispersion phosphate nodules with White et al., 1958 leads to small enough diffusion distances for radon-222

DISPOSAL OF DEPLETED URANIUM IN CLAY

Sampled water wells in Hoving, A., T. Kivits, and J. Griffioen. TNO 2024 R12632





PRELIMINARY CONCLUSIONS

First looking at radionuclides that move fast → Gaseous decay product of uranium

- Presence of radon in sand formations may not come uranium in clay
- Phosphate nodules so far only found in glauconitic sands

- **Disposal of depleted uranium may not add to already existing radiotoxicity in sand formations**

ANY QUESTIONS?

Thank you for your attention

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