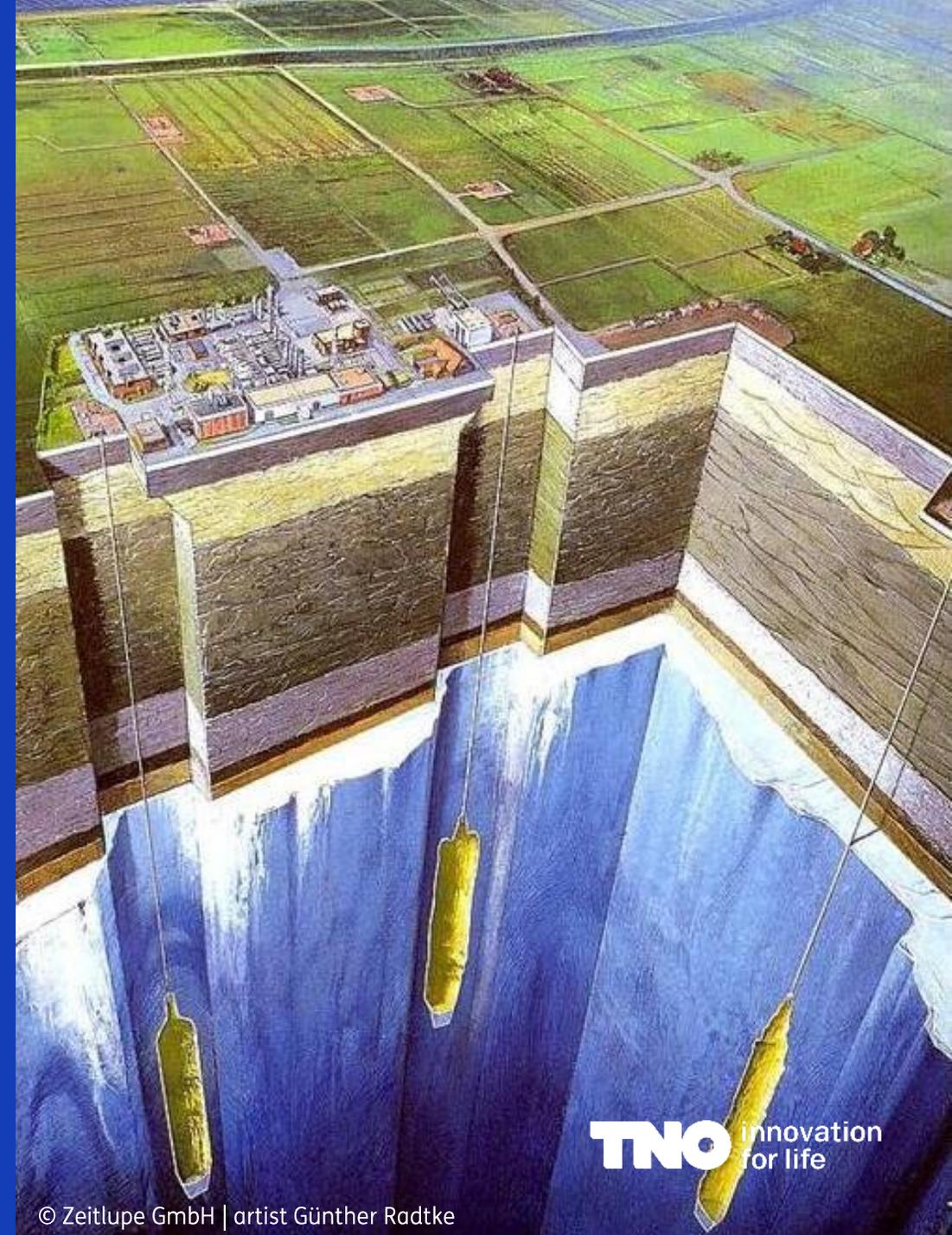


Salt Mining and Storage in The Netherlands

PAST, PRESENT (AND FUTURE)

Remco Groenenberg | TNO-Geological Survey of The Netherlands

Proceedings in Salt Cavern Uses and Abandonment, Utrecht, 16 October 2024

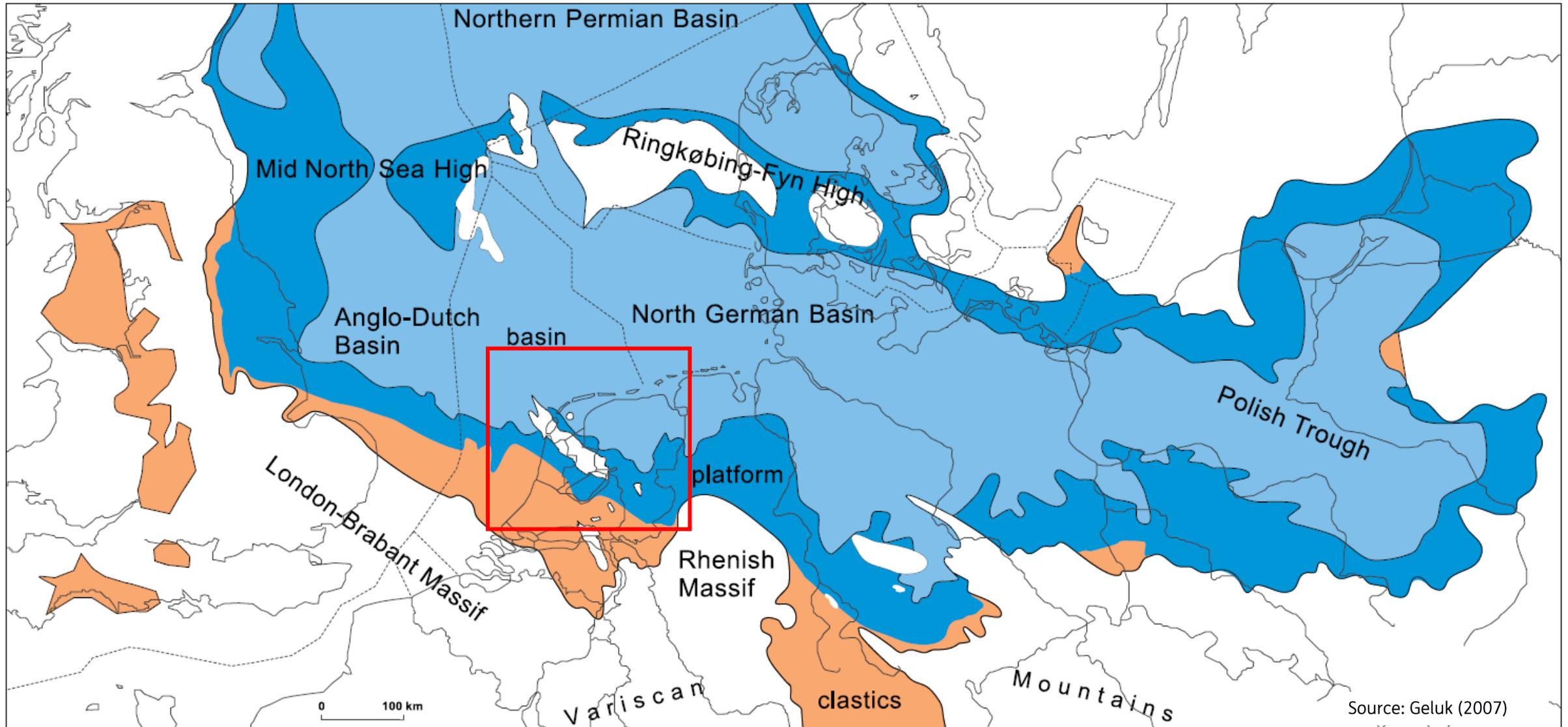


The Netherlands approx. 255 million years ago...



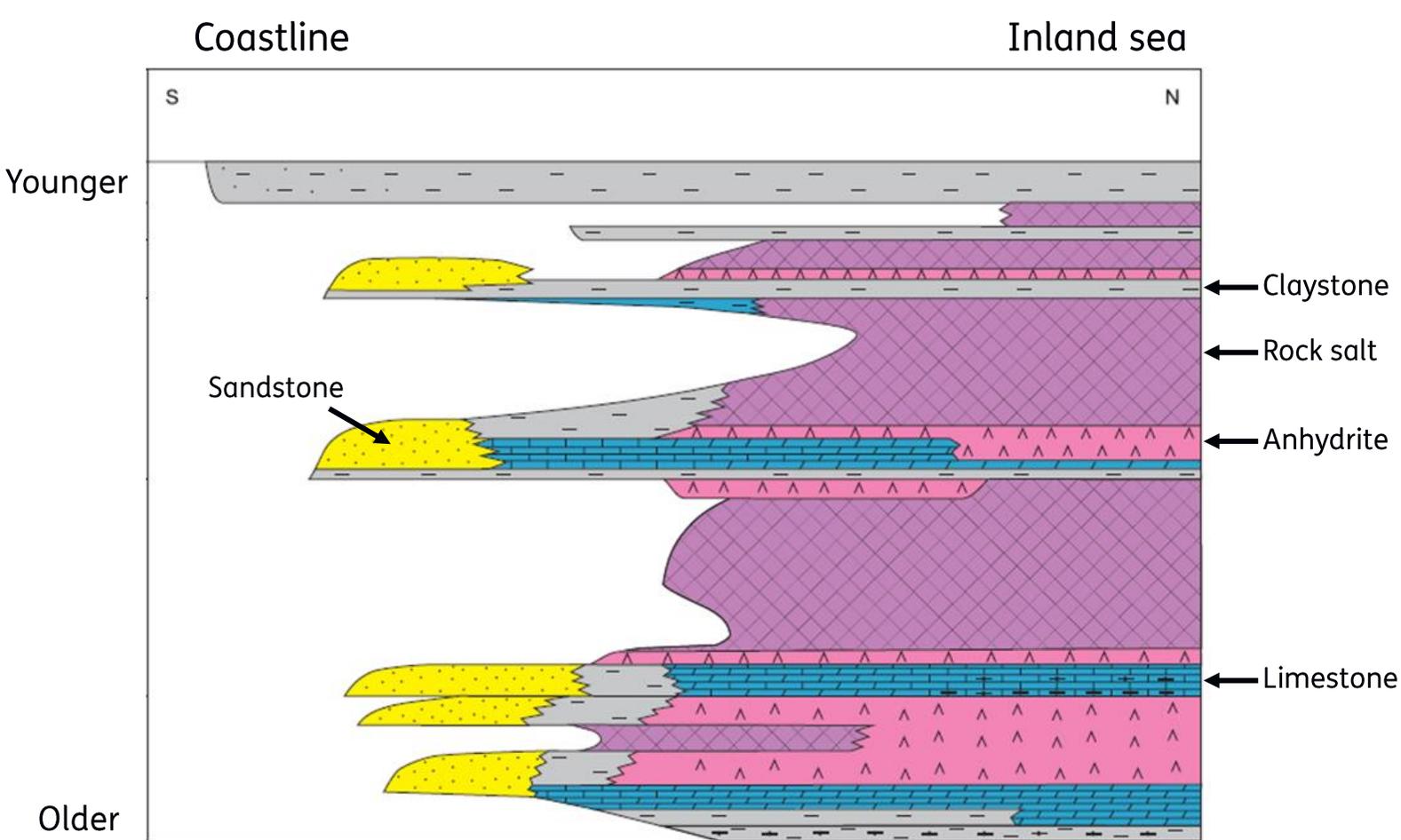
Source: dinosaurpictures.org
C.R. Scotese (2013)

Large parts of N-Europe covered by a shallow inland sea

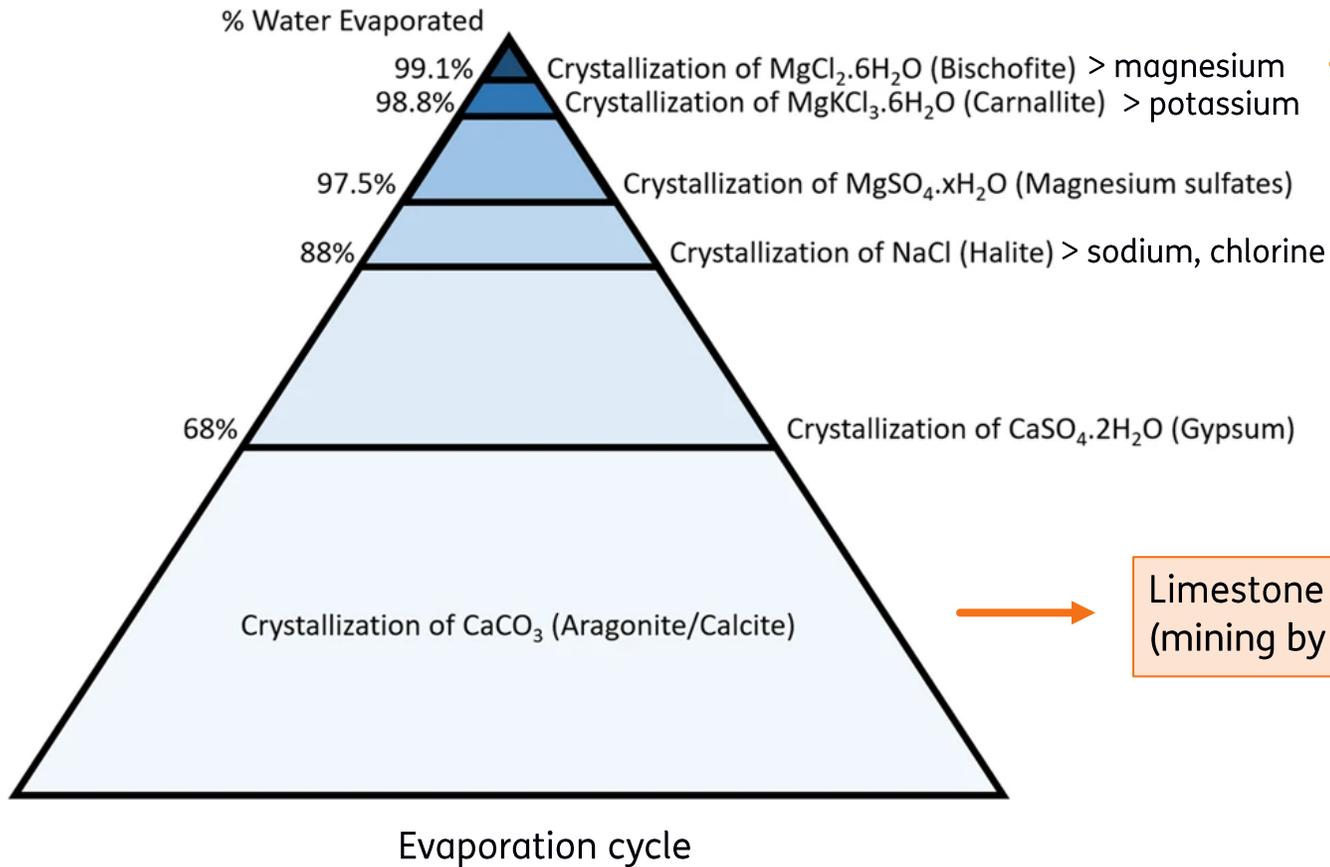


Source: Geluk (2007)

> 500m of layered deposits : salts, limestone and anhydrite



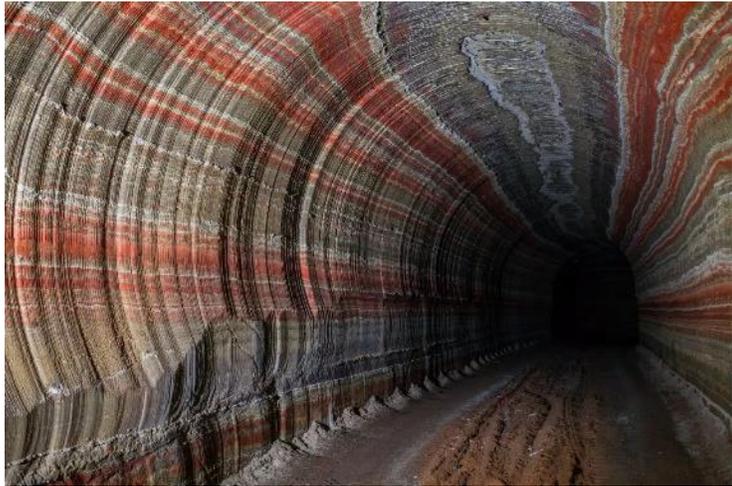
Sequence of deposition of different types of salt



Nedmag, Veendam
Rare

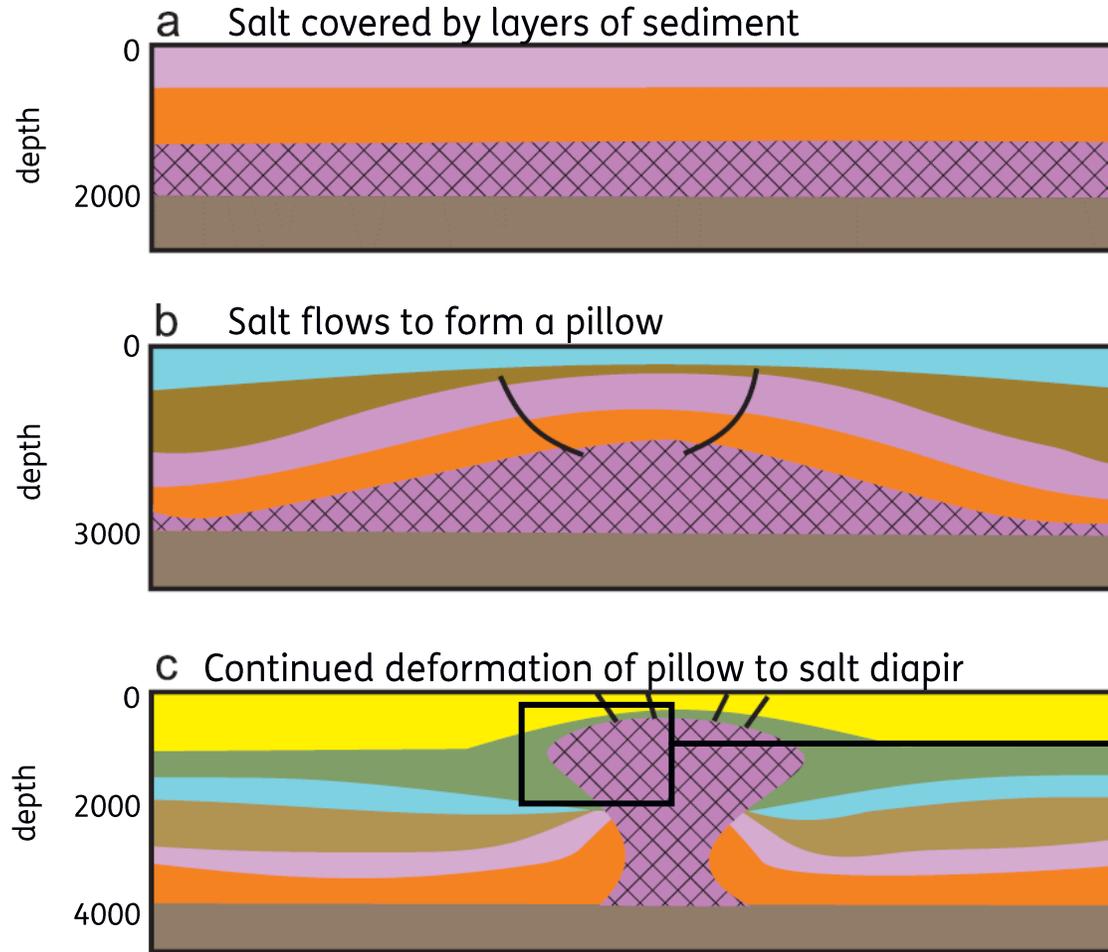
Conventional salt mining
Commonly used in NL
Nobian, Frisia

Limestone
(mining by excavation)



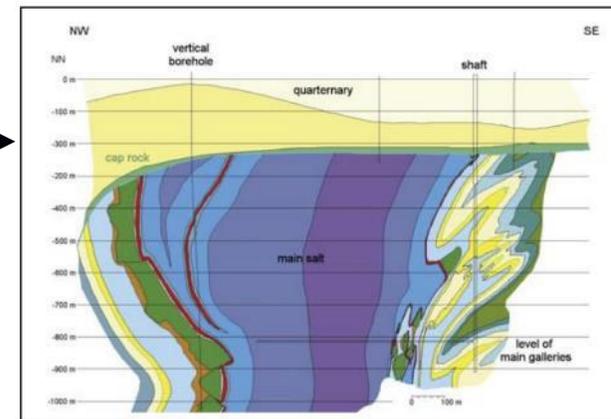
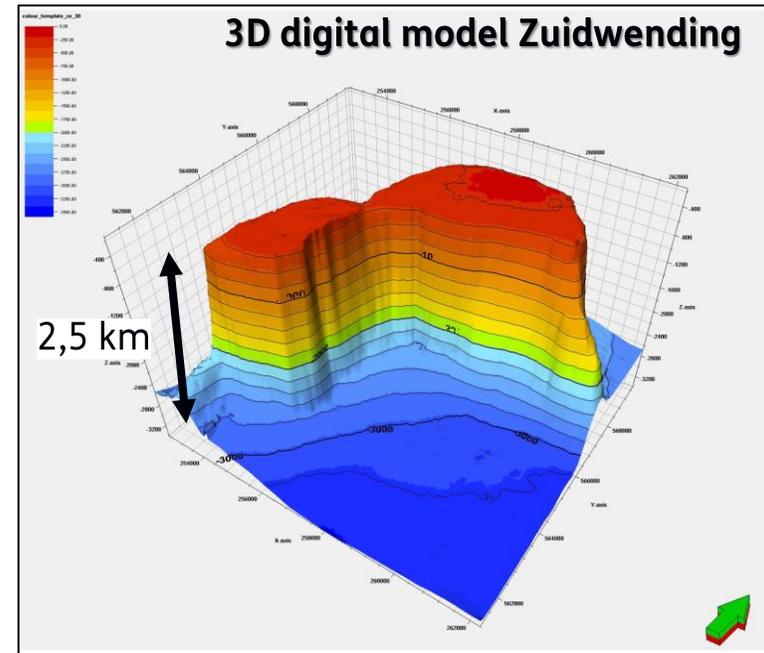
Source: Basel Abu Sarah et al, 2022

Formation of salt pillows and salt diapirs



Source: Geluk et al., 2017, Geology of the Netherlands

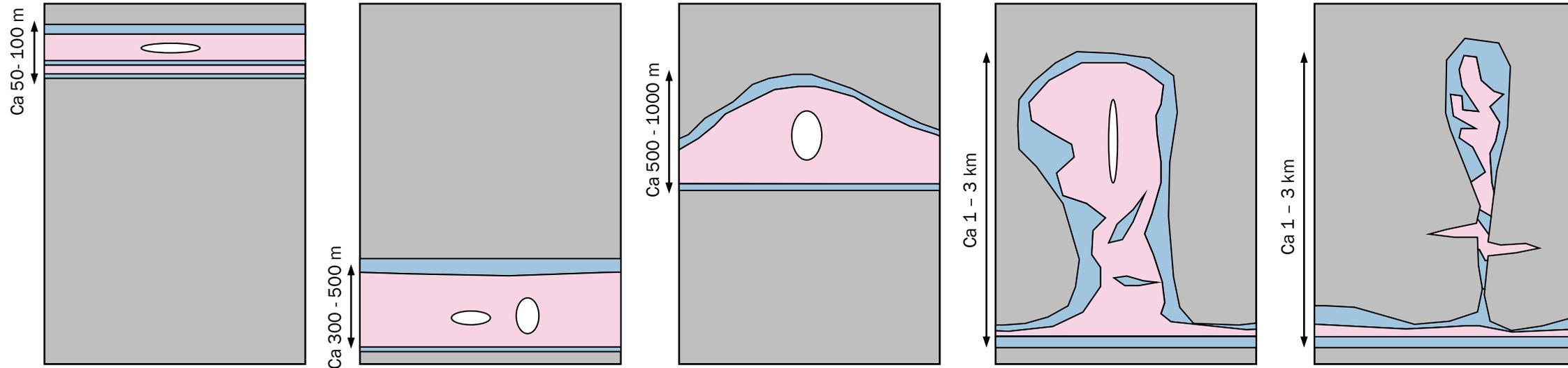
 Salt deposits



Source: Gundelach et al., 2013

Suitability of salt structures for salt mining and storage

Schematic examples of salt structures



Thinly layered
Depth < 500m

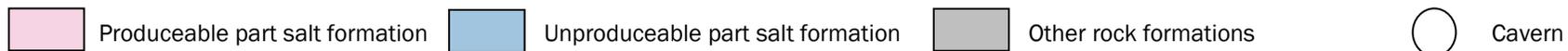
Thickly layered
Depth > 2000m

Salt pillow
Depth 700 - 1500m

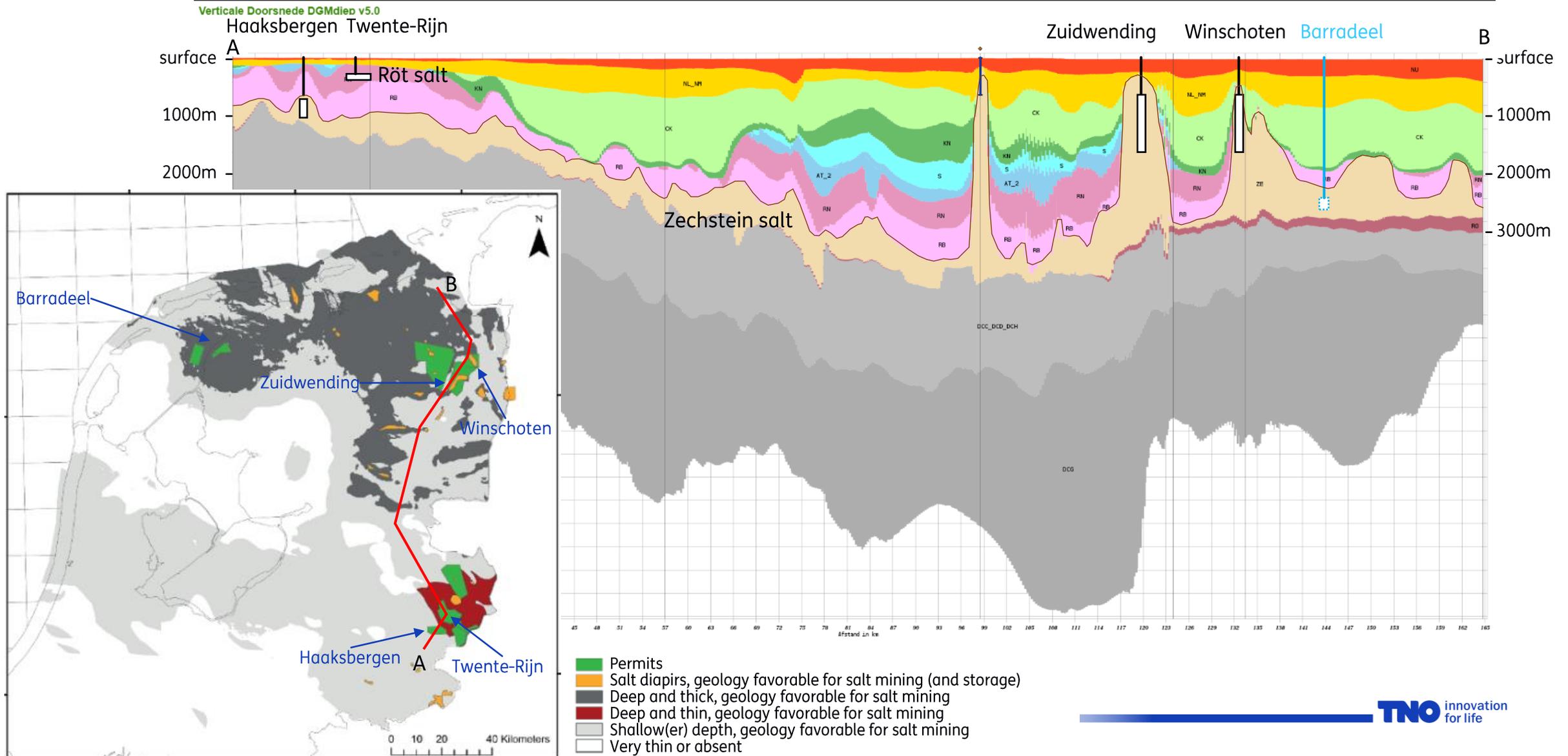
Salt diapir
Depth 700 - 1500m

Salt diapir
Depth 700 - 1500m

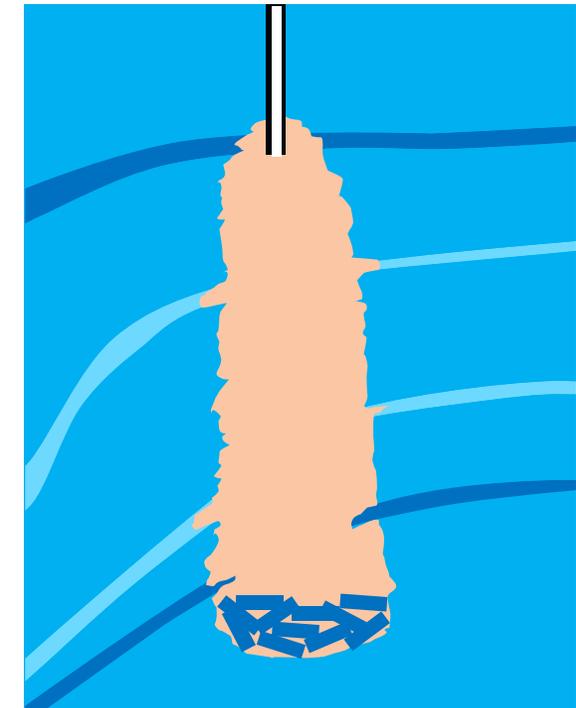
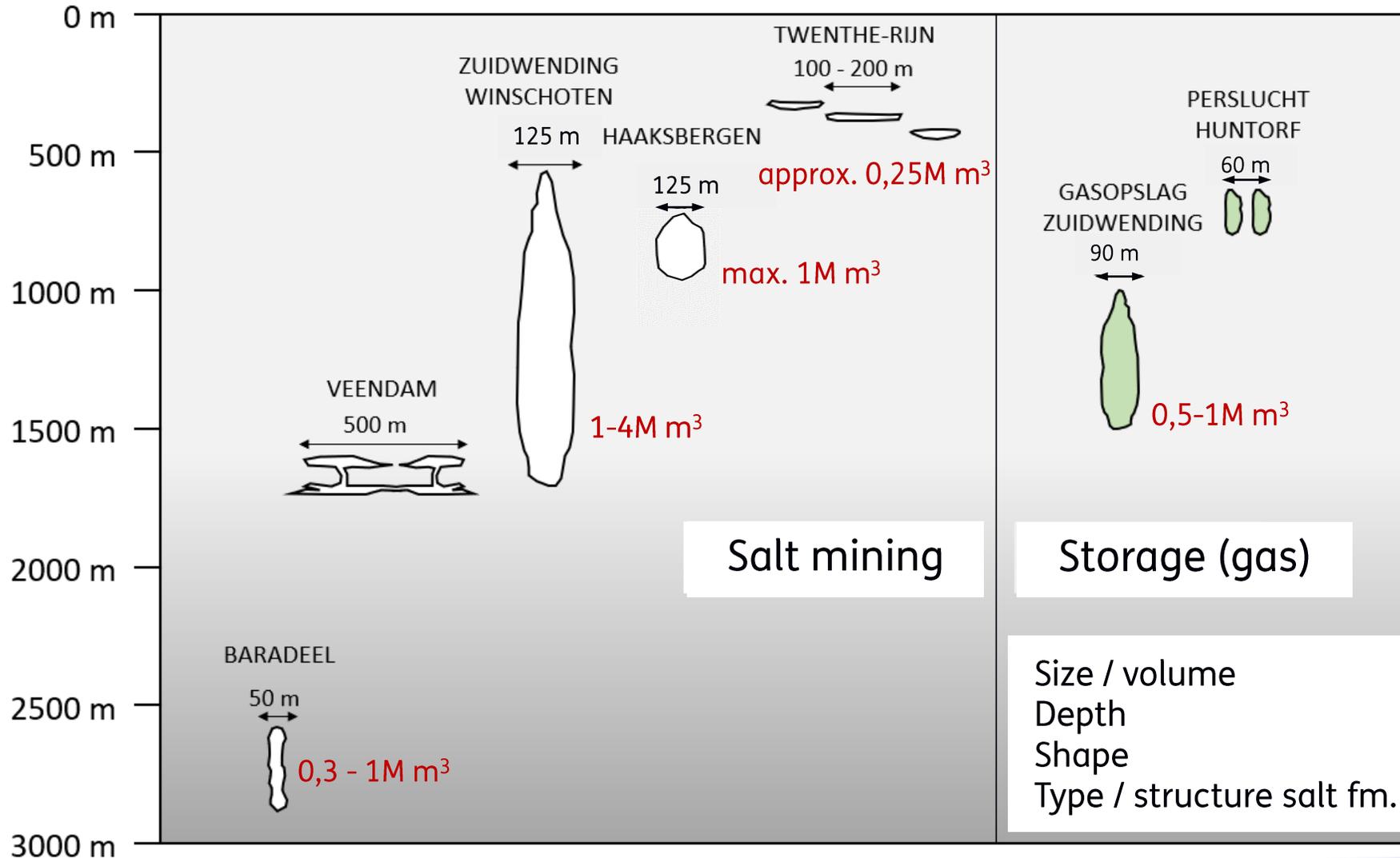
Salt mining	favorable	favorable	favorable	favorable	unfavorable
Storage	unfavorable	unfavorable	favorable	favorable	unfavorable



Salt presence and extraction areas in The Netherlands

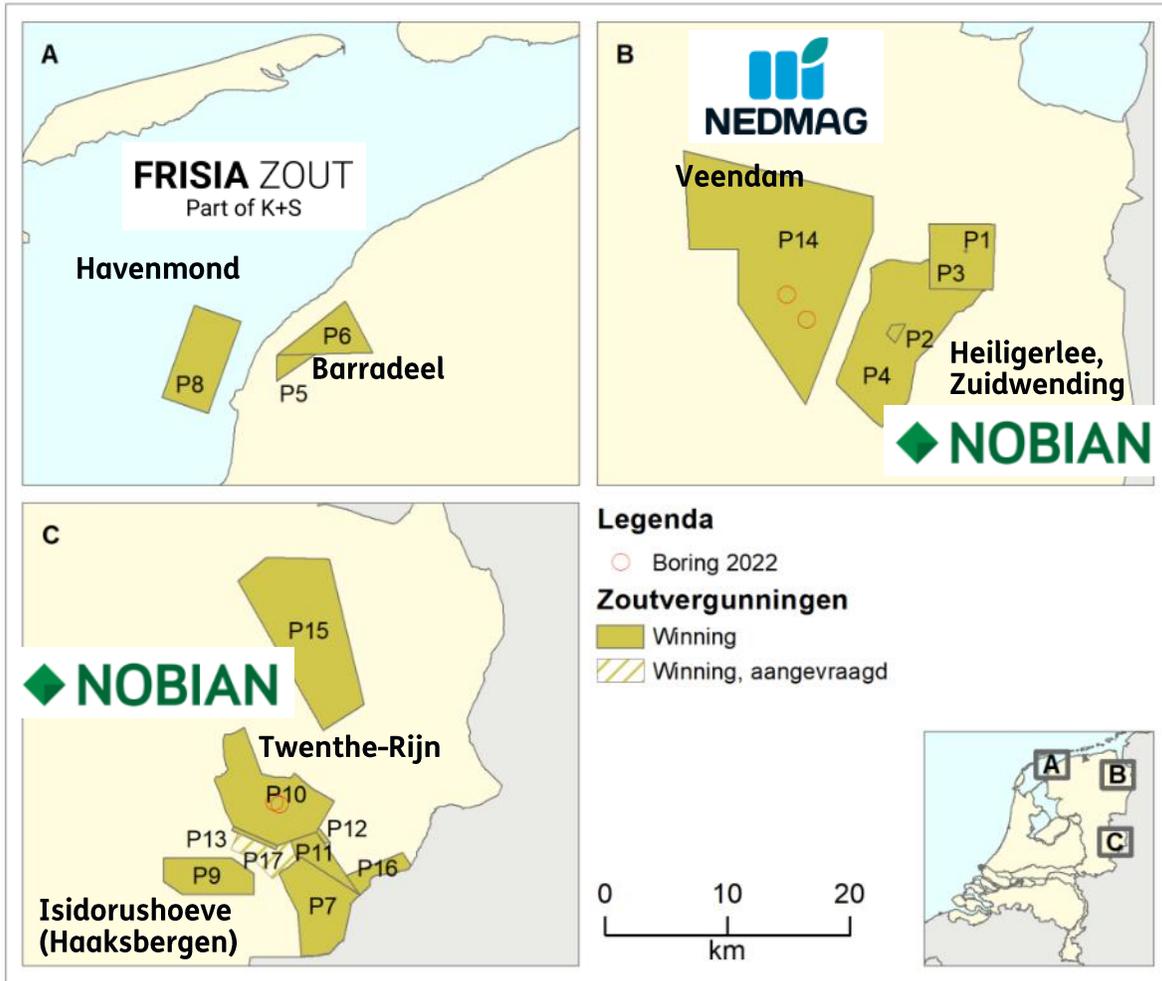


Large differences between salt caverns between locations

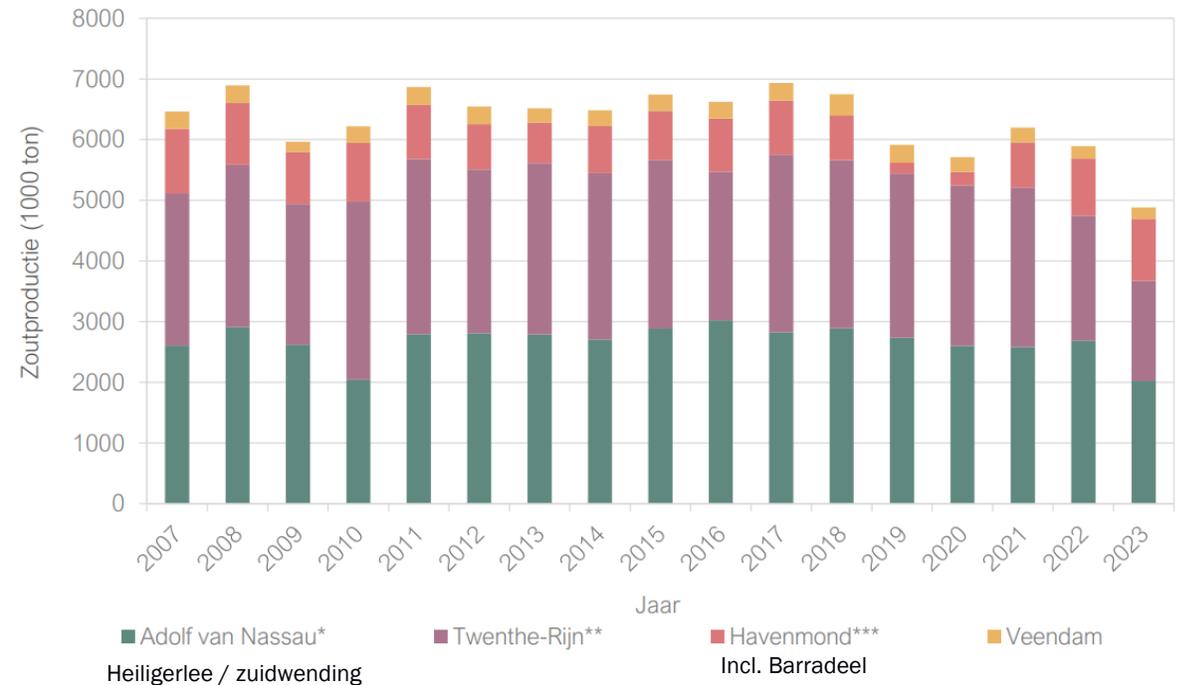
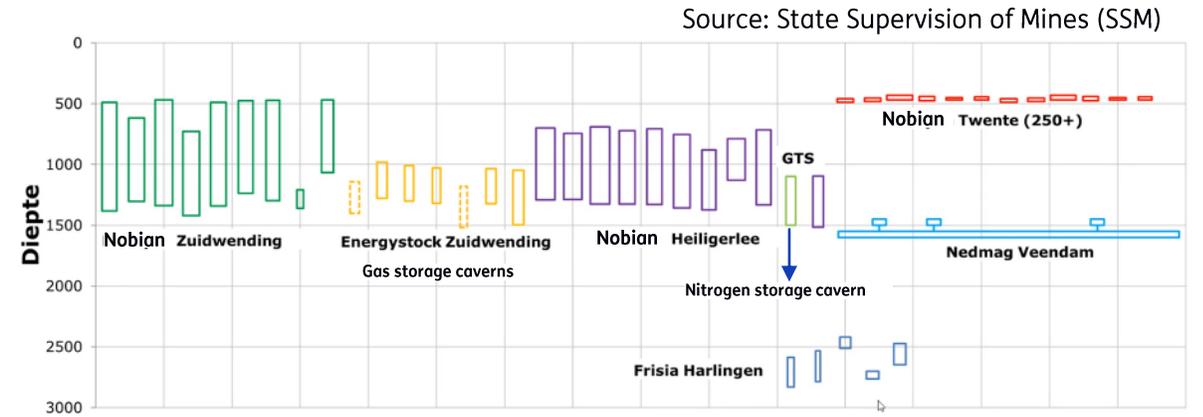


-  Normal rock salt (halite)
-  Poorly soluble (e.g. anhydrite)
-  Soluble (e.g. carnallite)
-  Brine
-  Insoluble residue ("sump")

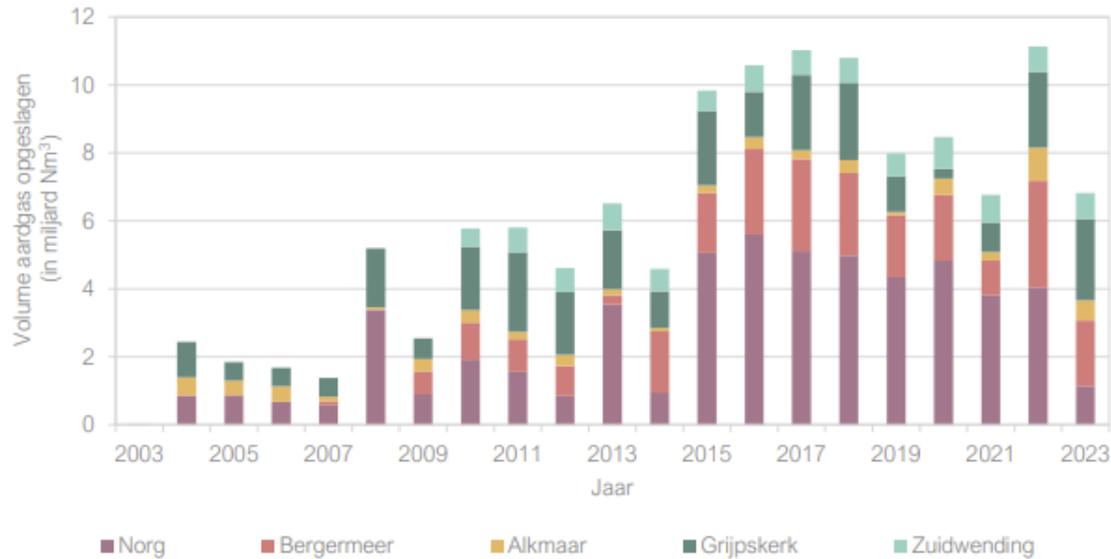
Salt production in The Netherlands



Source: annual report “[delfstoffen en aardwarmte in Nederland 2023](#)”



Storage in The Netherlands



Figuur 4.2 Opgeslagen volume aardgas per UGS van 2003-2023.

7 storages operational of which 3 in salt caverns

- Gas storage Zuidwending (6 caverns)
- Nitrogen storage Heiligerlee/Winschoten (1 cavern)
- Oil storage Enschede (2 caverns)

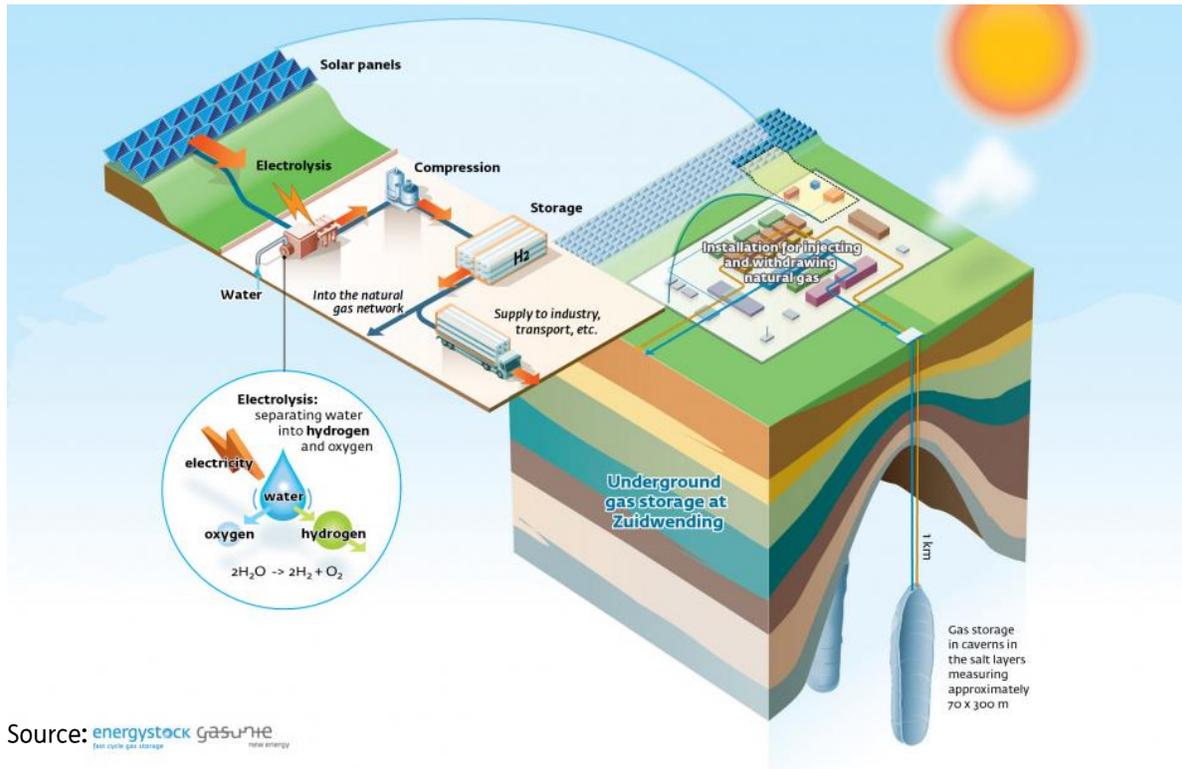


Figuur 4.1 Opslagvergunningen per 1 januari 2024.

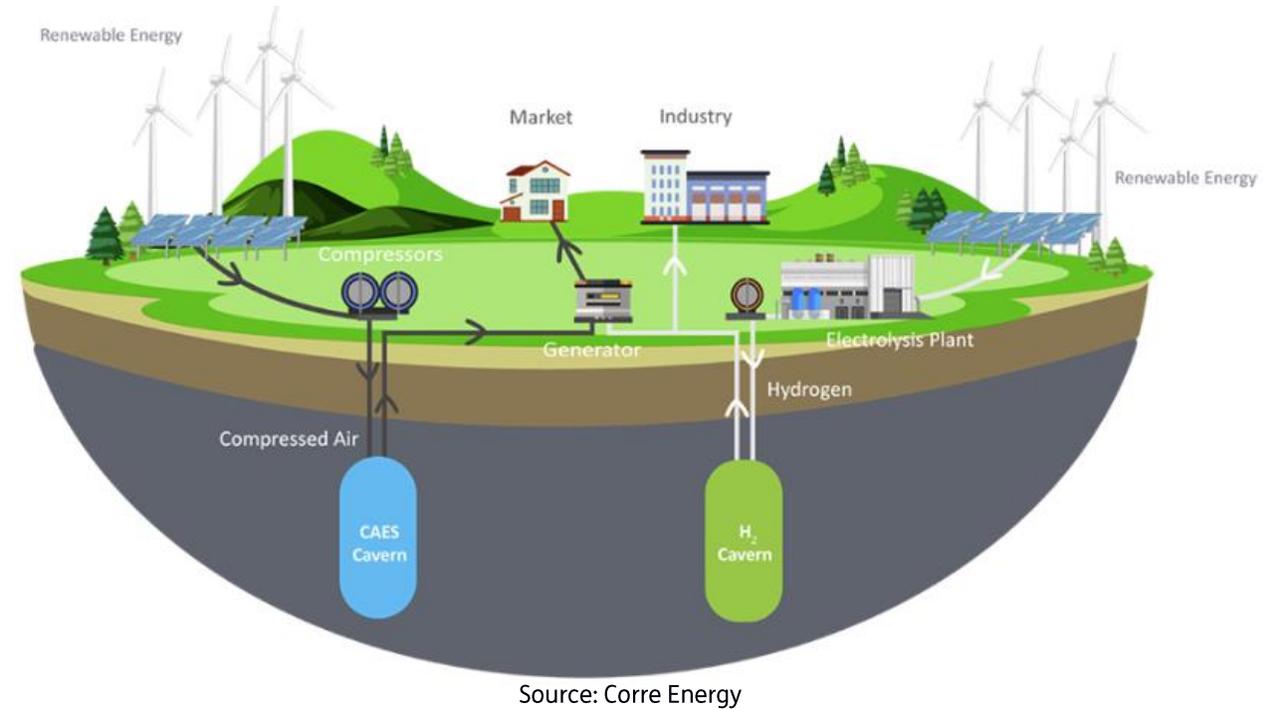
Source: annual report “[delfstoffen en aardwarmte in Nederland 2023](#)”

What will the future hold?

Hydrogen Storage?



Compressed Air Energy Storage?



Knowledge development

Current research questions that are subject of recent/ongoing research

- Many caverns have reached the end of their lifetime.
 - How can they be safely abandoned (shut-in)?
 - Can they be safely reused for storage (e.g. hydrogen)?

Cavern Closure Consortium (CCC)

Integrated multiscale study of salt cavern abandonment in the Netherlands.

Completed in 2024

Salt R&D program TNO-AGE

UU-TNO PhD research on fundamental aspects of salt creep and application in models

Expected in 2026

KEM-17

Research on the long-term risks of cavern abandonment

Completed in 2021

KEM-28

Risk assessment for underground hydrogen storage in (clusters of) salt caverns.

Completed in 2024

Solution Mining Research Institute

International network of experts and operators.

Diverse studies ongoing

Research TU-Delft

PhD research on seismicity around salt caverns (4 years)

Expected in 2026

KEM-45

Effects of Controlled Brine Bleed-Off (CBBO)

Expected in 2026

A detailed microscopic view of a mineral specimen, showing a complex, layered, and crystalline structure. The colors range from dark grey to light grey, with some areas appearing more translucent. The texture is highly irregular and fractured. A central black rectangular box contains the text "Thank you for listening!".

**Thank you for
listening!**