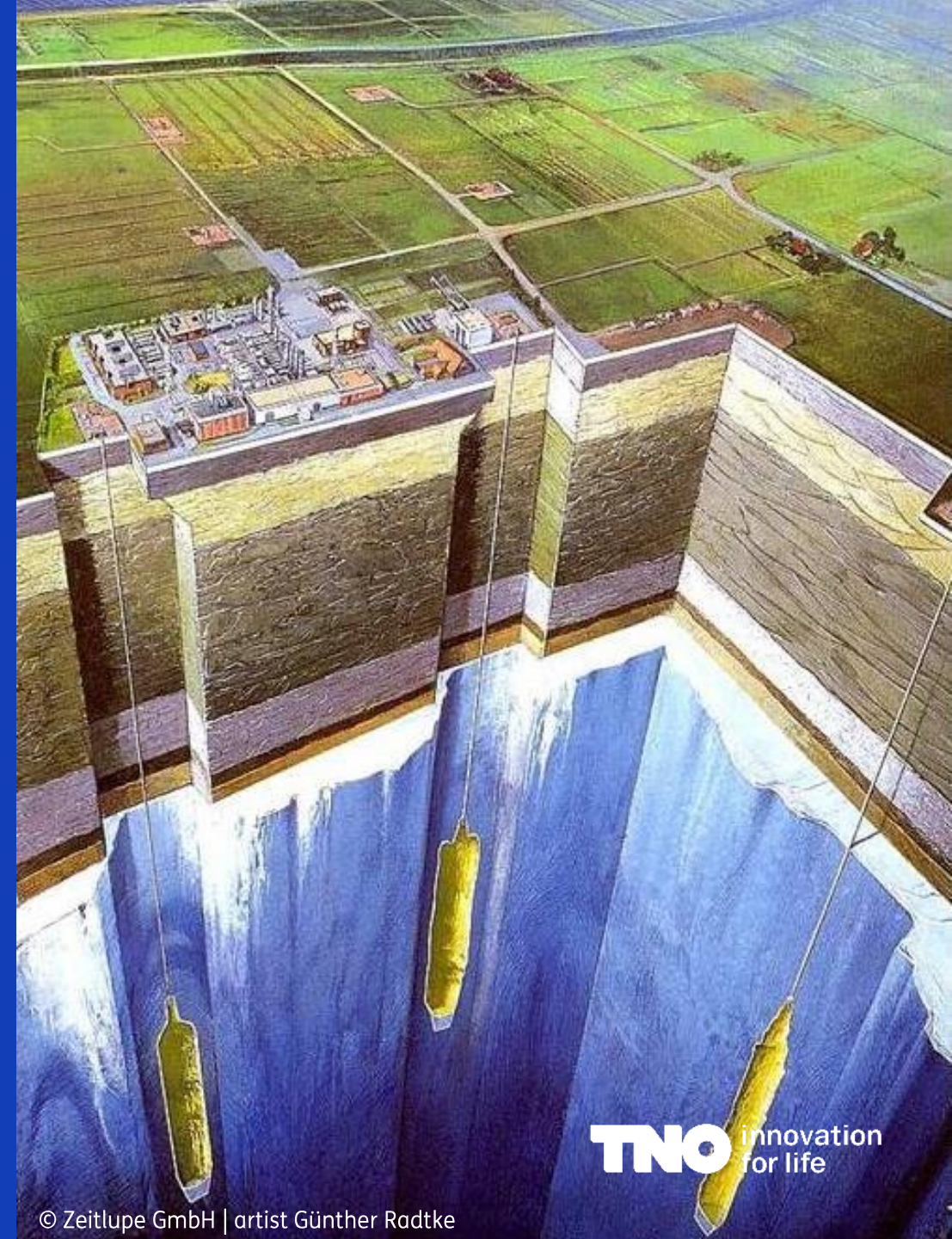


# Salt Mining and Storage in The Netherlands

PAST, PRESENT (AND FUTURE)

Remco Groenenberg | TNO-Geological Survey of The Netherlands

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

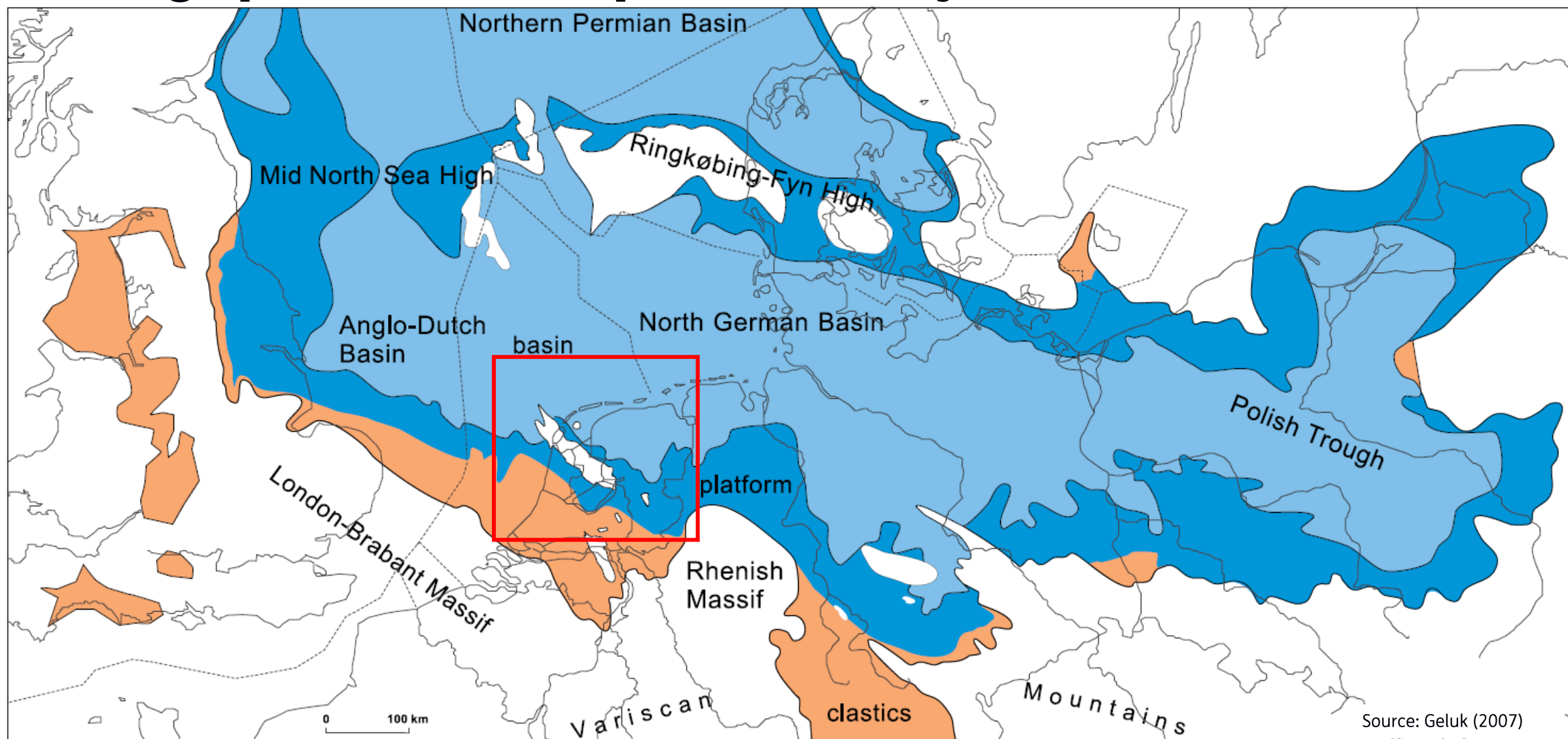




# The Netherlands approx. 255 million years ago...

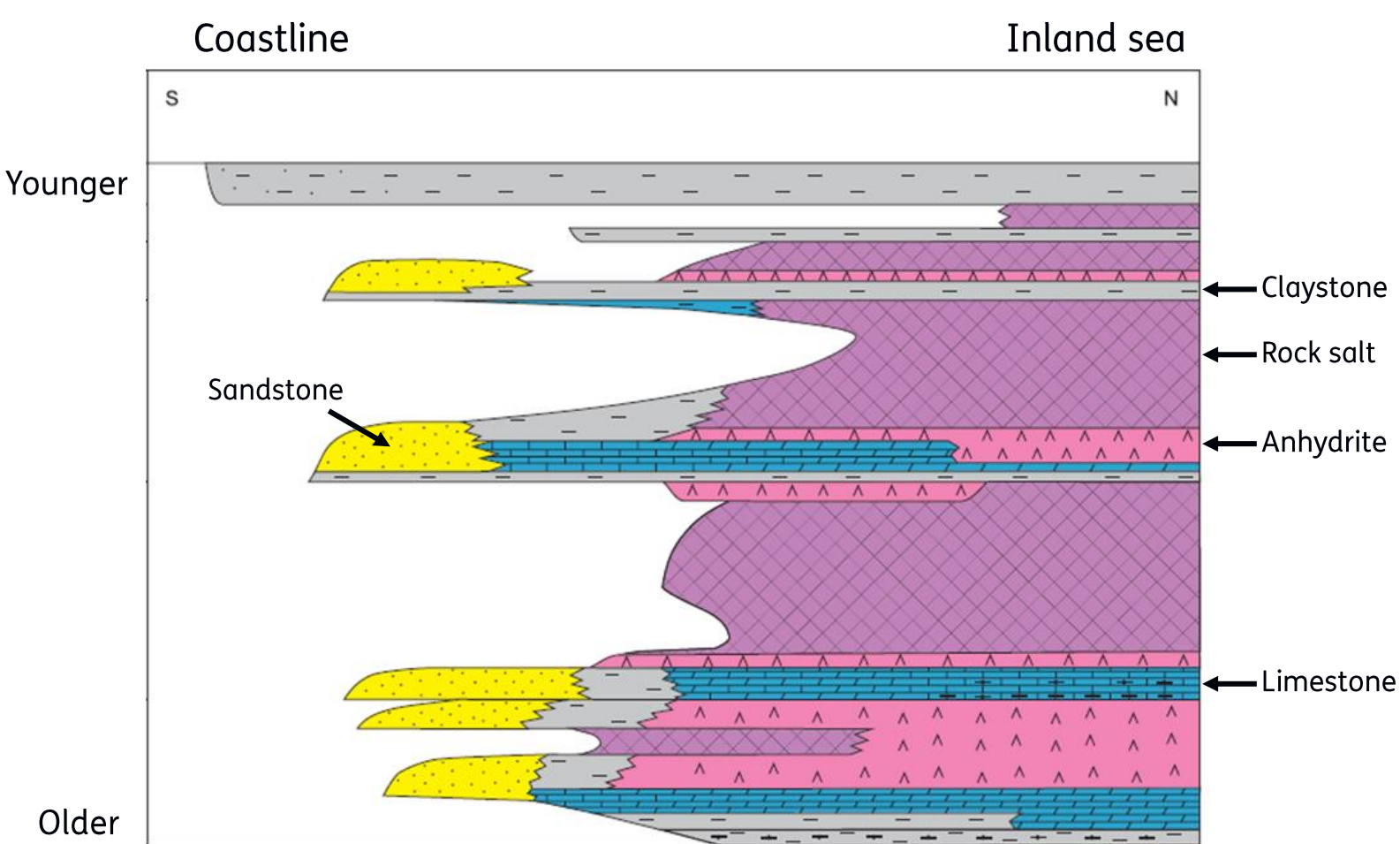


# Large parts of N-Europe covered by a shallow inland sea

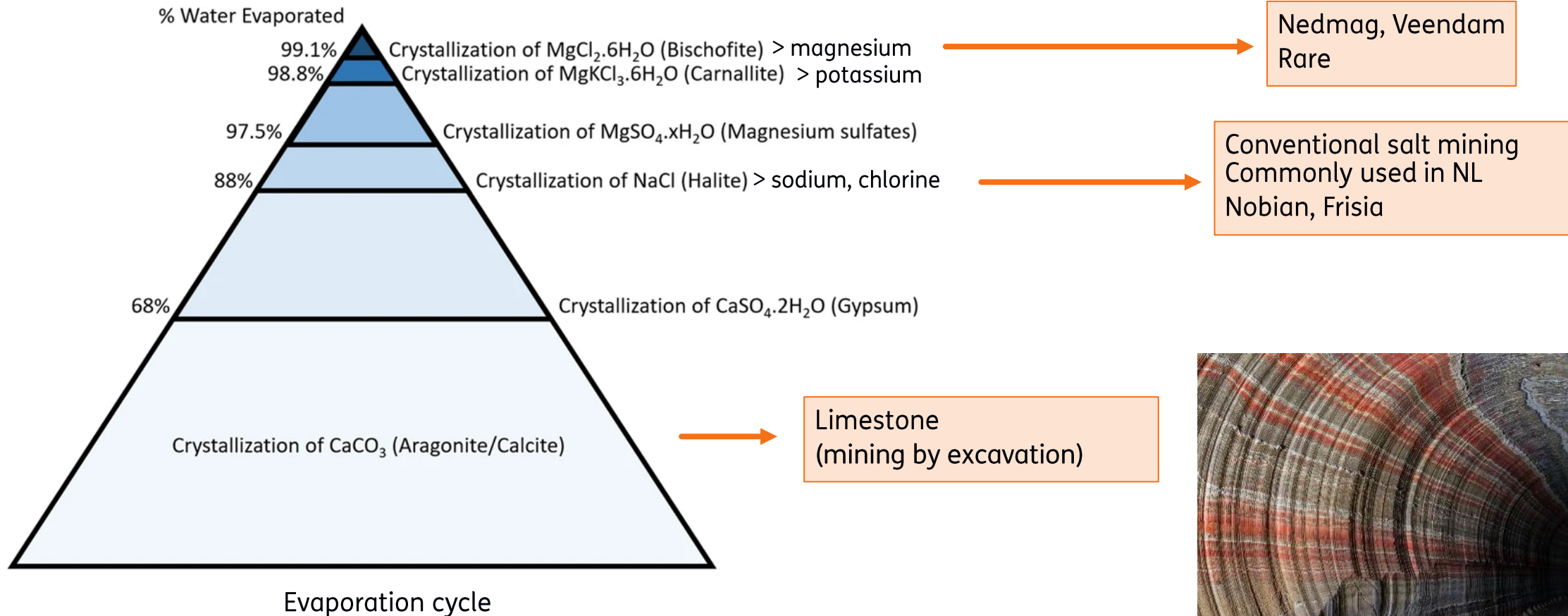




# > 500m of layered deposits : salts, limestone and anhydrite



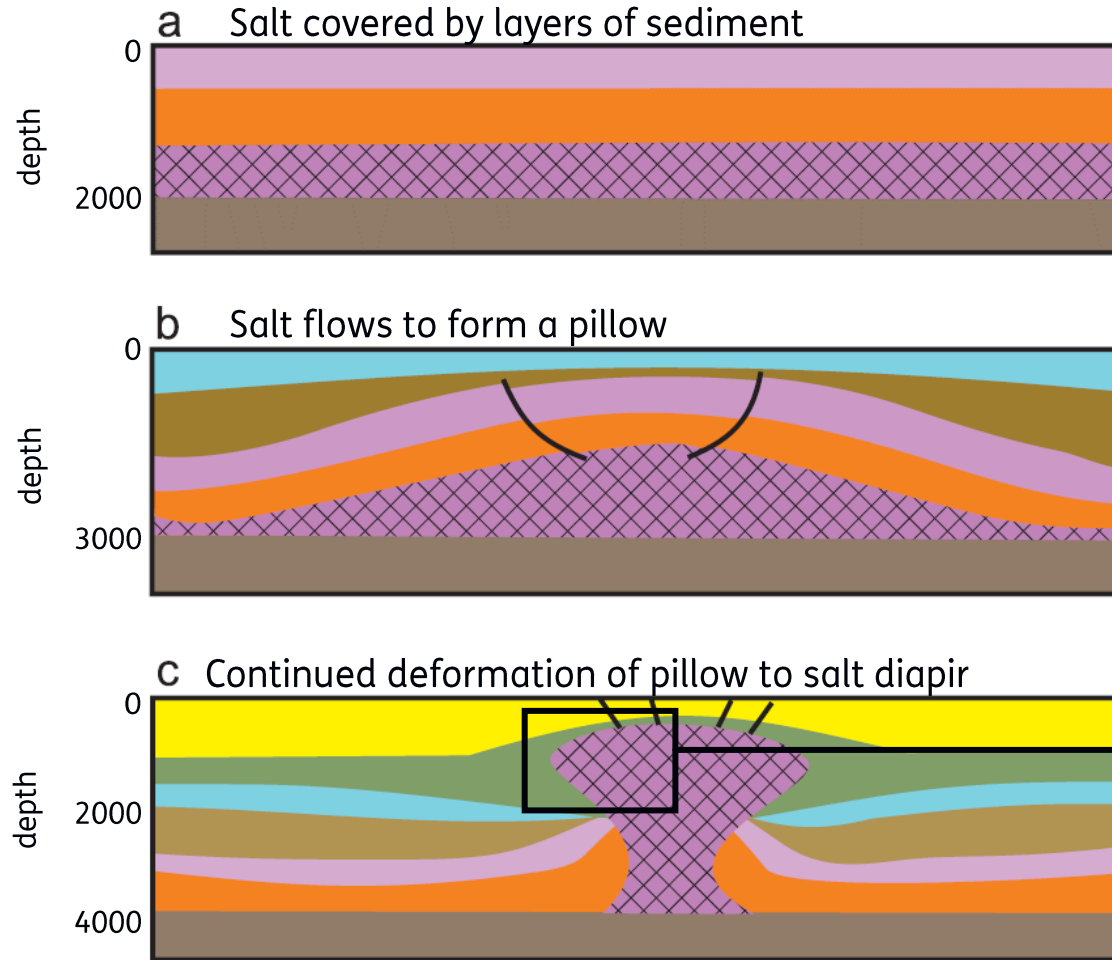
# Sequence of deposition of different types of salt



Source: Basel Abu Sarah et al, 2022

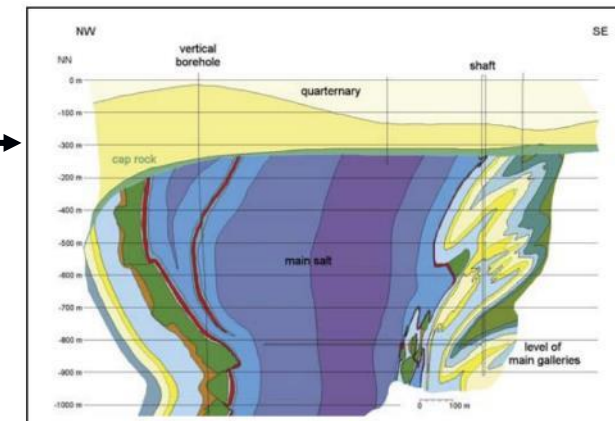
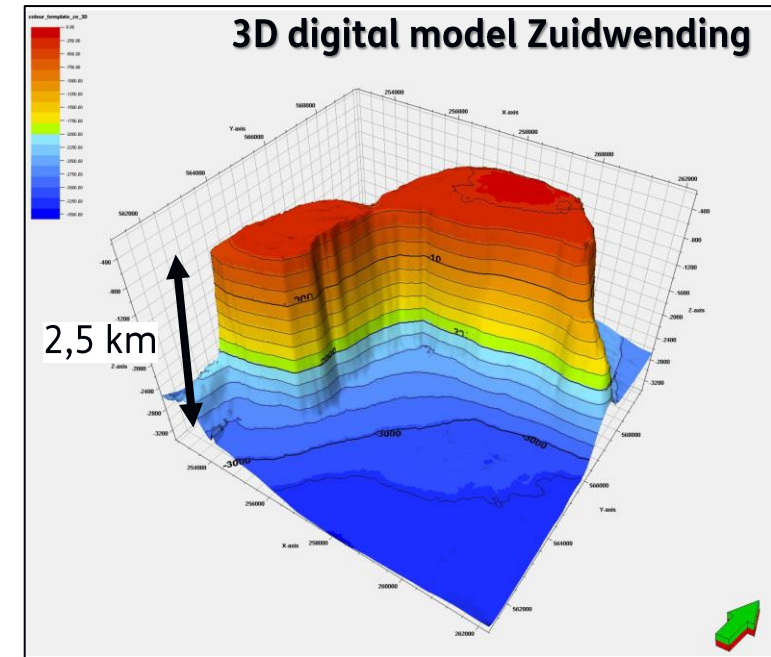


# Formation of salt pillows and salt diapirs



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

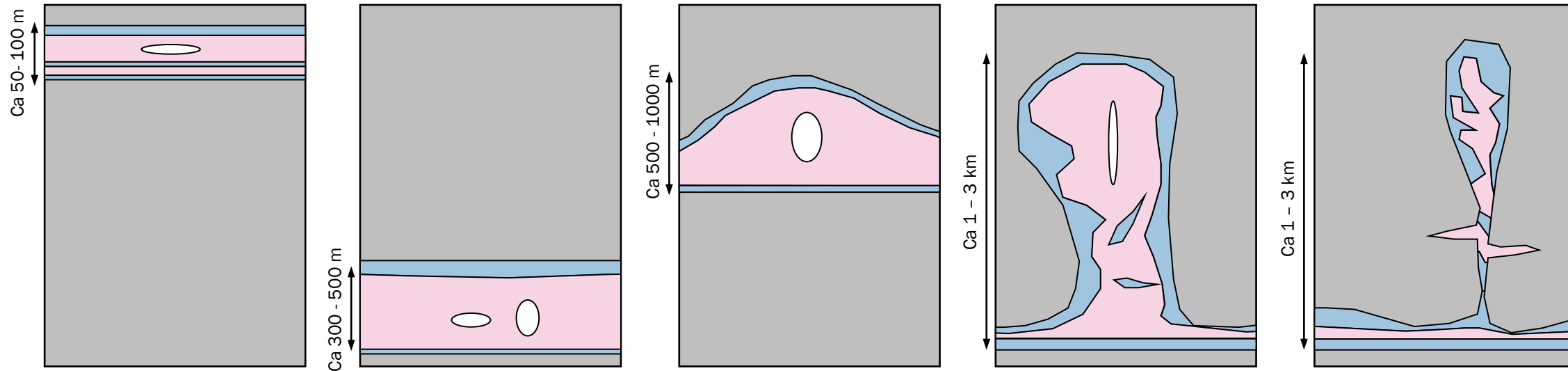
 Salt deposits



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

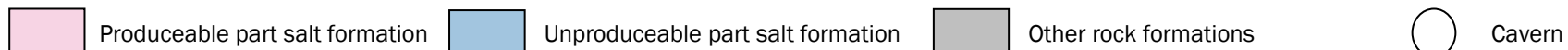
unfavorable

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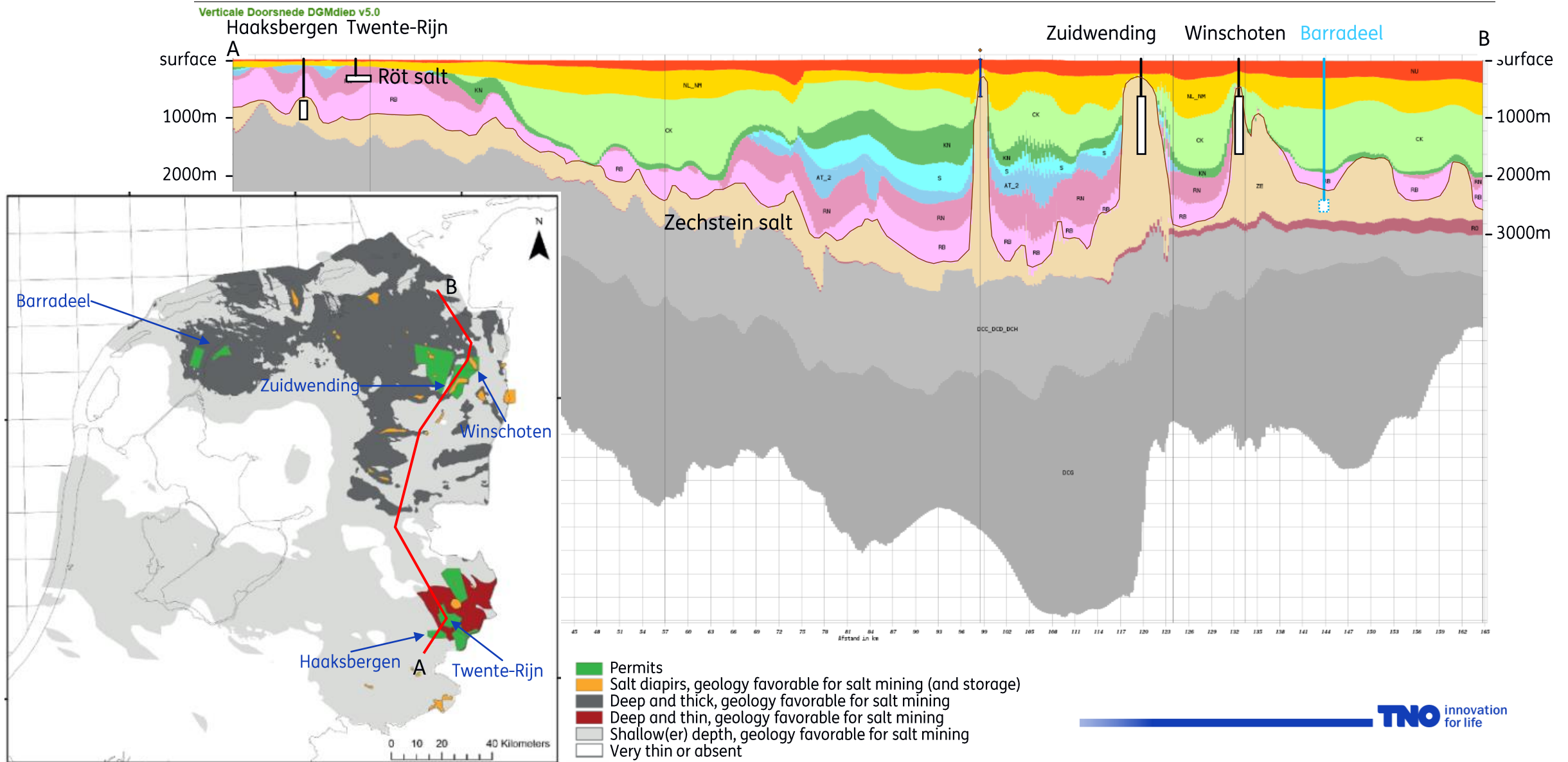
favorable

unfavorable



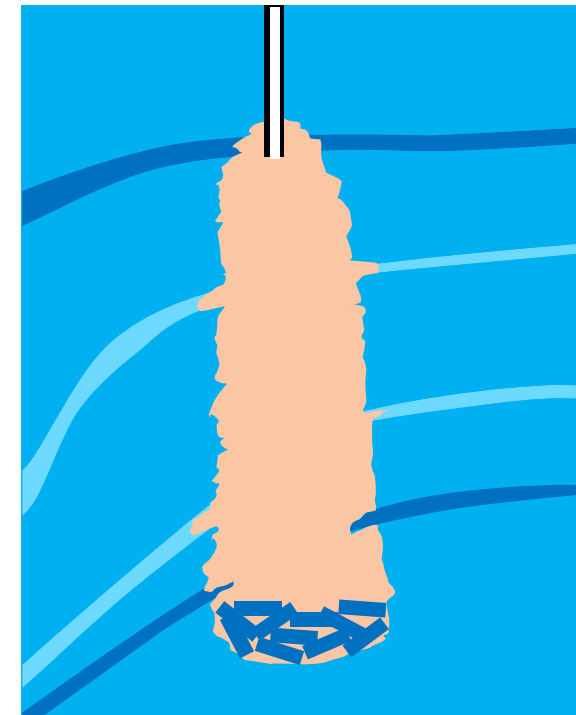
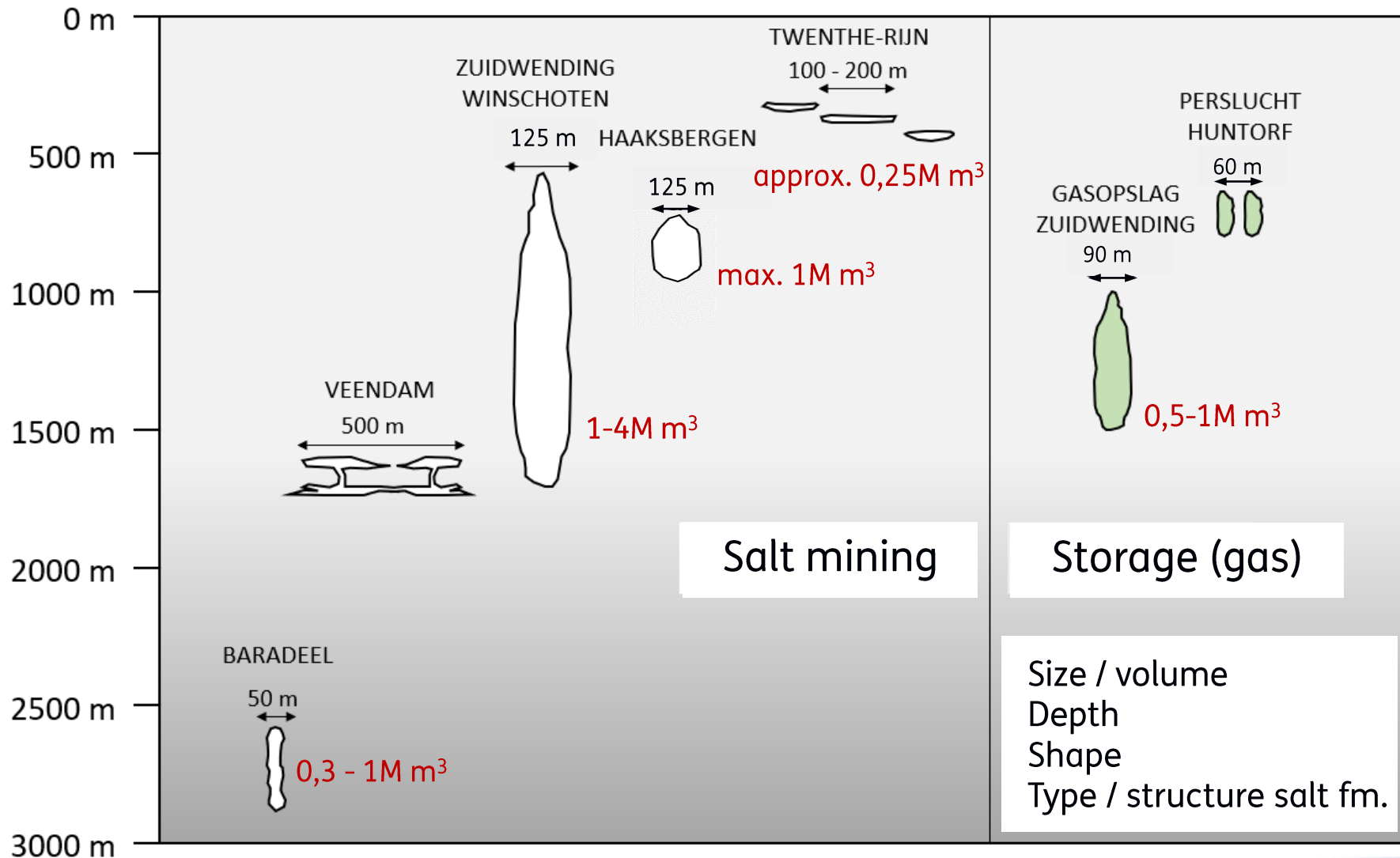


# Salt presence and extraction areas in The Netherlands



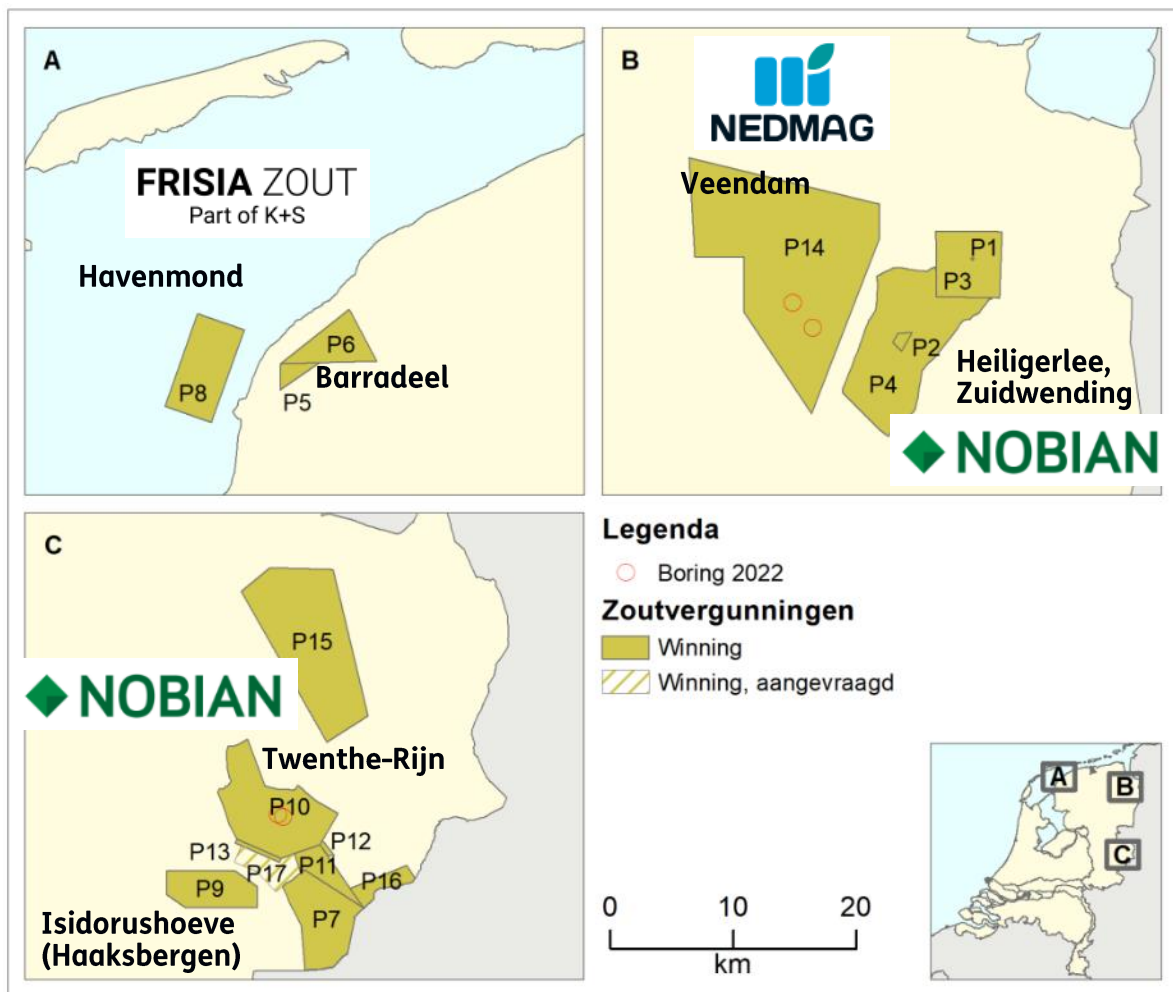


# Large differences between salt caverns between locations



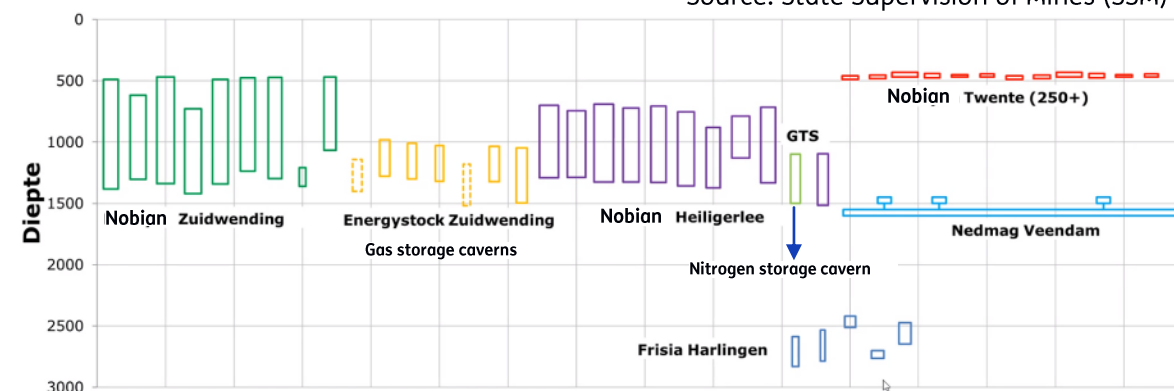
- Normal rock salt (halite)
- Poorly soluble (e.g. anhydrite)
- Soluble (e.g. carnallite)
- Brine
- Insoluble residue ("sump")

# Salt production in The Netherlands



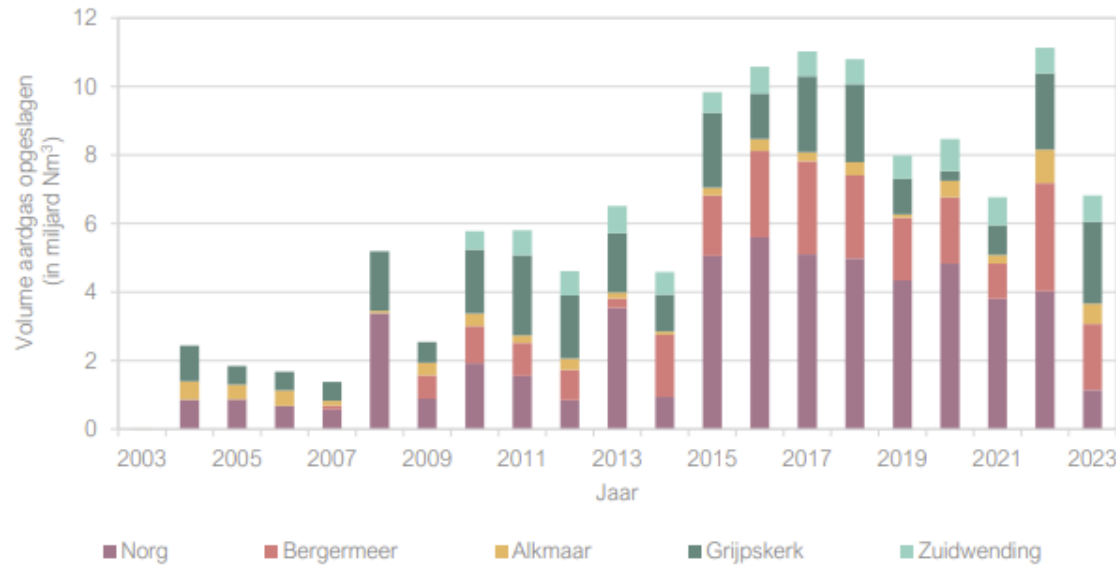
Source: annual report “[delfstoffen en aardwarmte in Nederland 2023](#)”

Source: State Supervision of Mines (SSM)





# 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)

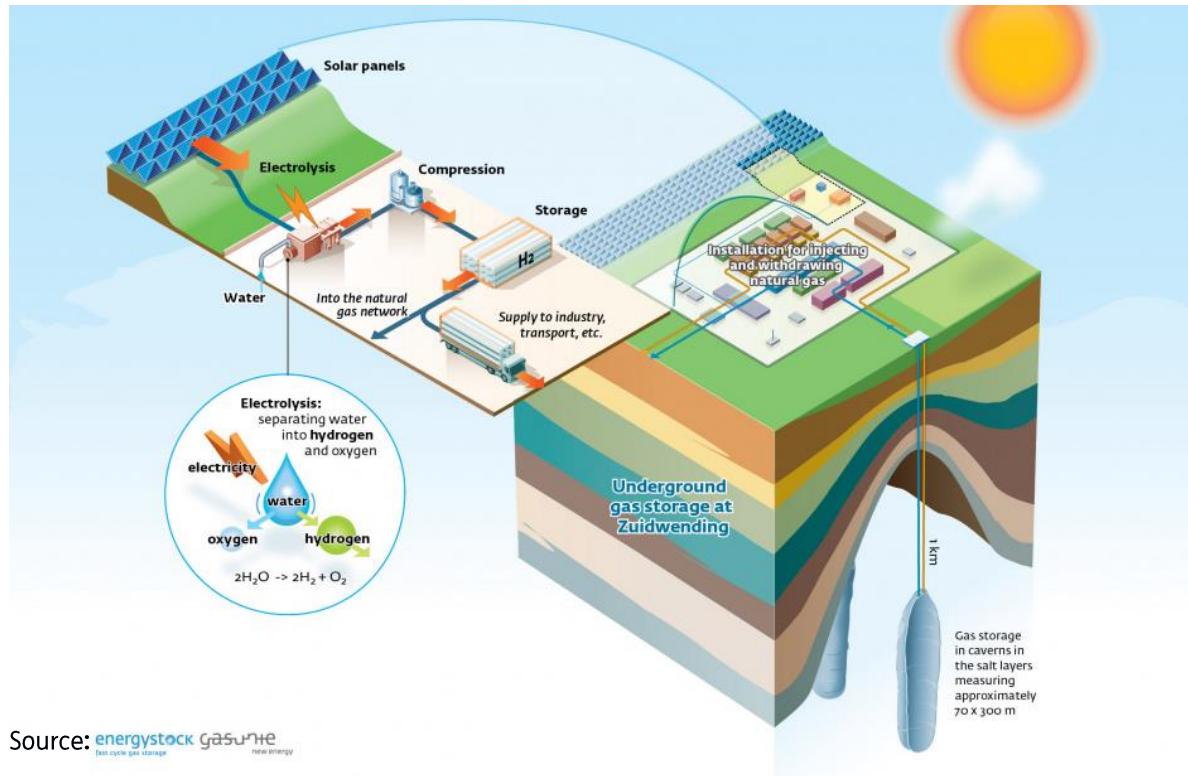


Figuur 4.1 Opslagvergunningen per 1 januari 2024.

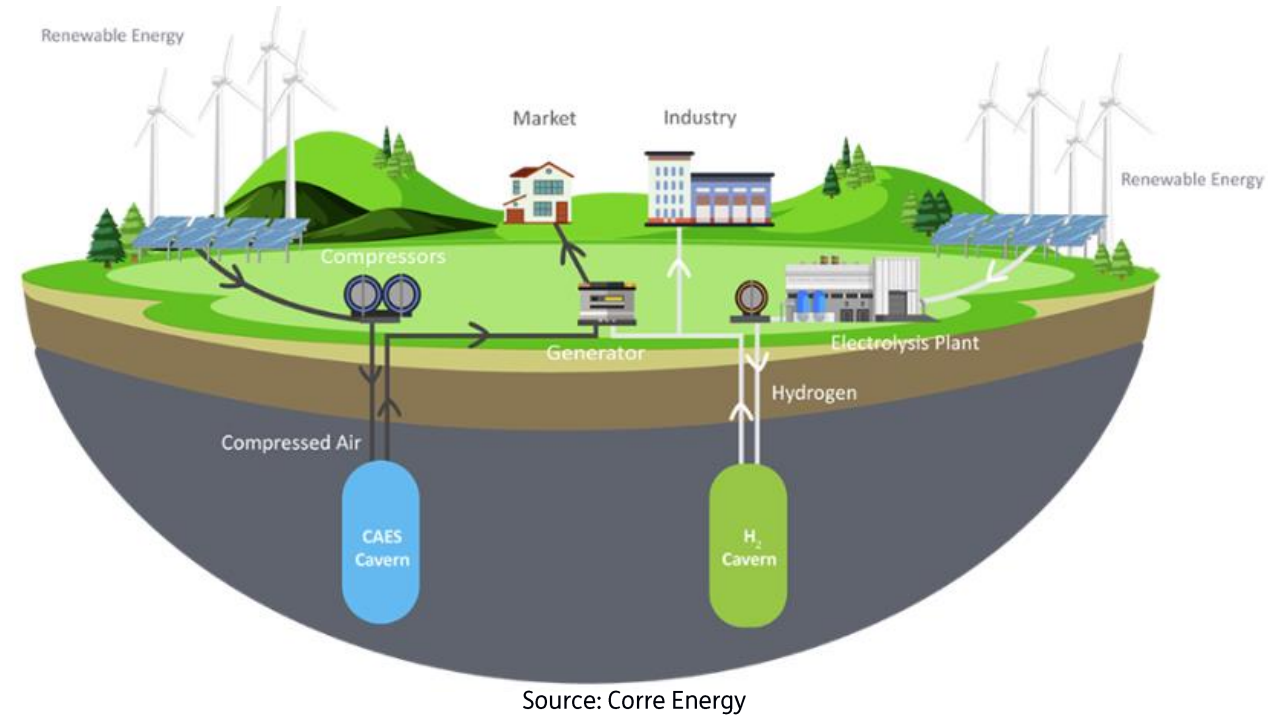
Source: annual report “[delfstoffen en aardwarmte in Nederland 2023](#)”

# 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-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

### **KEM-17**

Research on the long-term risks of cavern abandonment

Completed in 2021



**Thank you for  
listening!**