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# State of the art cavern abandonment at Nedmag

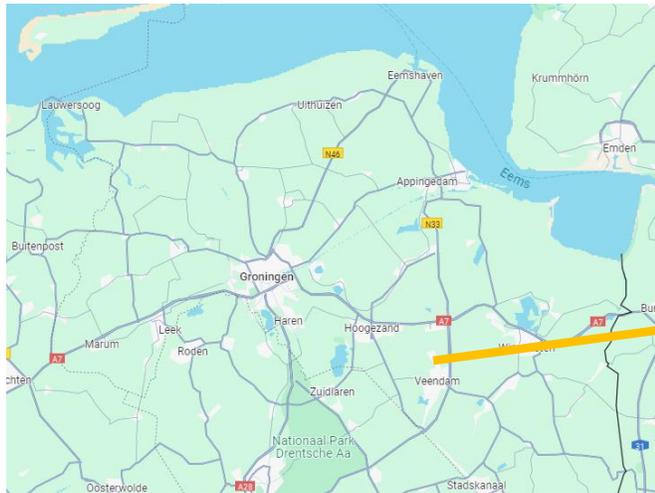
Proceedings in Salt Cavern uses and abandonment: Bridging the technical and social perspectives  
Salt Cavern Workshop 15 & 16 October 2024, Utrecht

# Summary

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- 7 years ago, at Nedmag, “*cavern*” abandonment was foreseen via hard shut in
- In 2018, despite low cavern pressure, a frac in the salt roof of one of Nedmag’s caverns occurred
- Cause: salt roof stress below cavern pressure
  - roof stress significantly below lithostatic, due to prolonged low cavern pressure
- After abandonment, cavern pressure will rise and new fracs are likely to occur
- Therefore, Nedmag’s caverns will be **bled off, prior to being shut in**
  - Possible as Nedmag’s caverns converge rapidly
  - As a result, abandoned cavern volumes will be limited
- Main advantages of pre-abandonment bleed off: minimum post-abandonment risks and subsidence
- (The pre-abandonment bleed off is included in the 2018 Mining plan)

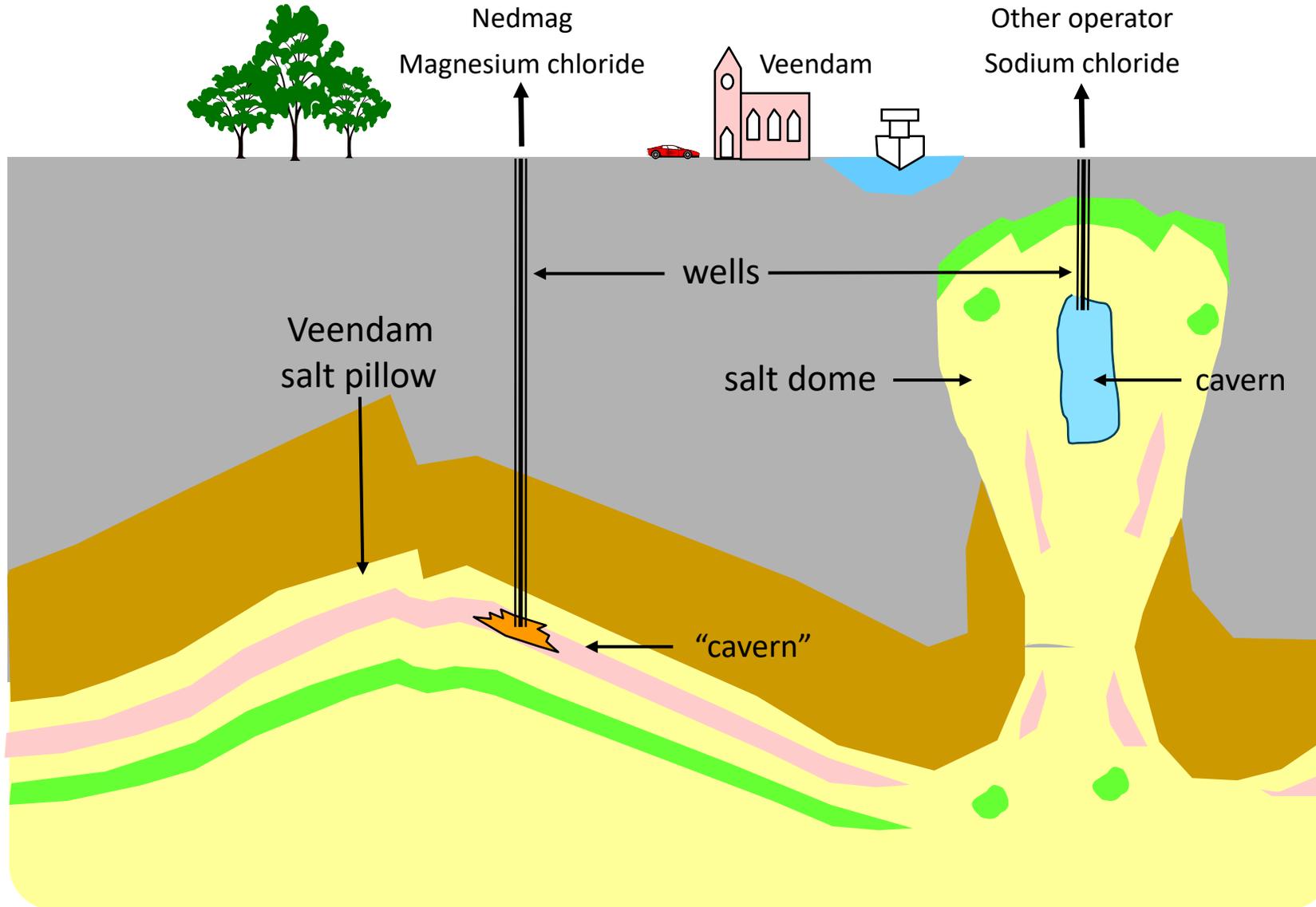
- Dutch company, founded 1972
- Located in Veendam



- Solution mining of magnesium chloride brine, for sale and captive use
- Production and worldwide sales of
  - solid magnesium chloride
  - Magnesium oxide and magnesium hydroxide
  - Calcium chloride



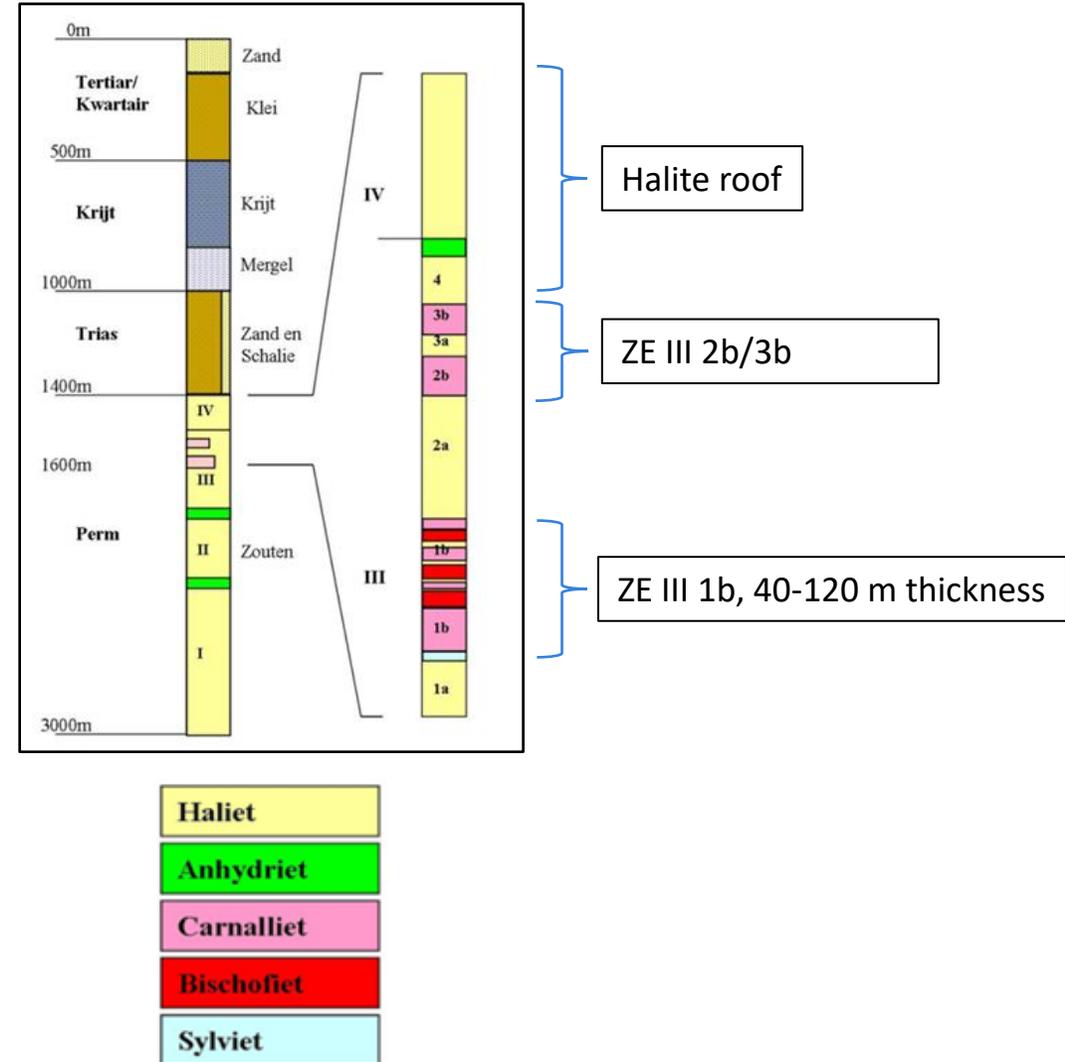
# Salt solution mining in Veendam



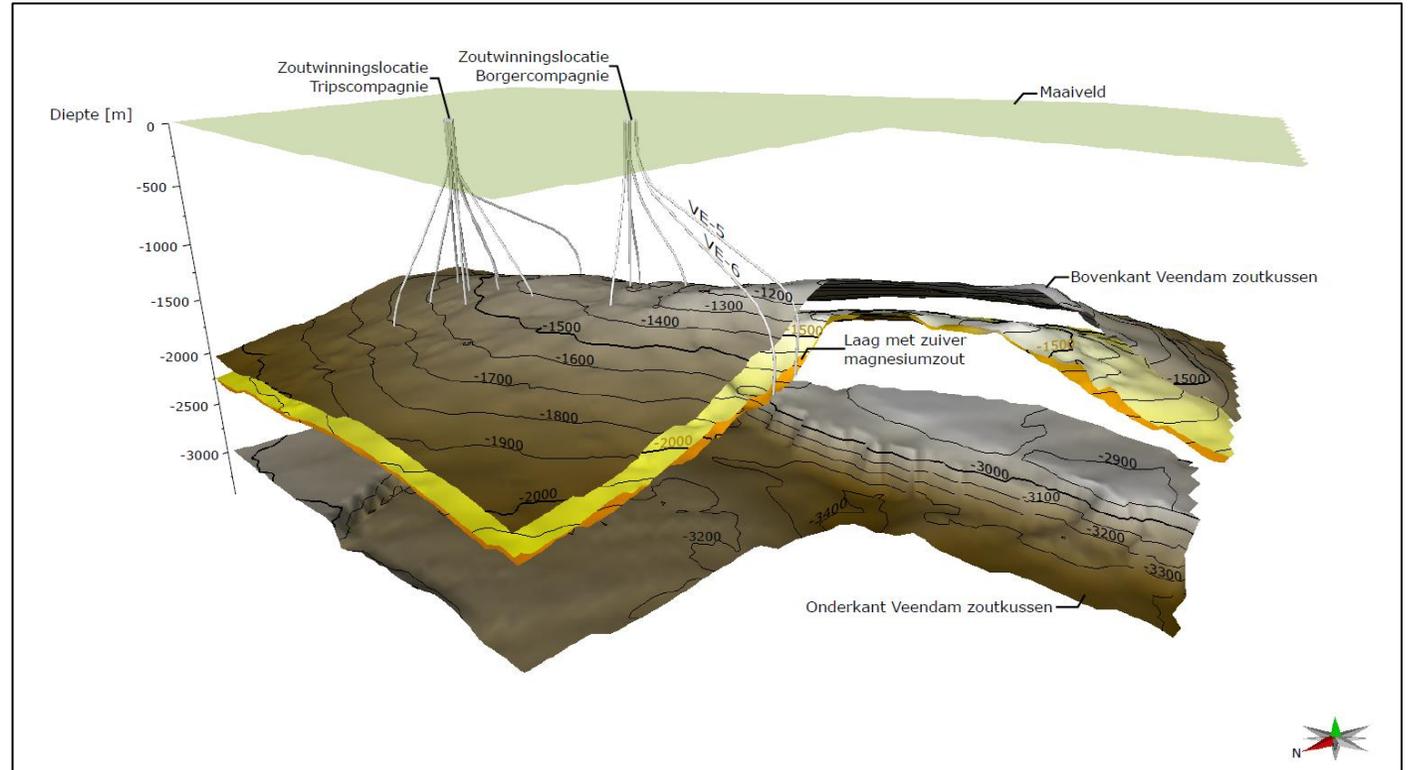
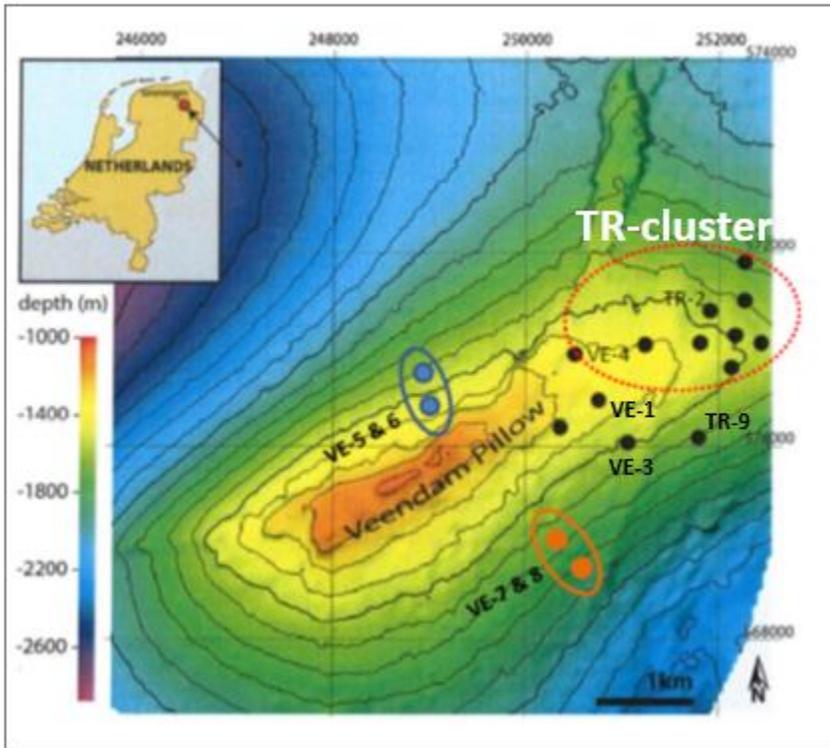
	Sand and clay
	Sand- and claystone
	Rocksalt (halite, NaCl)
	Layer with magnesium salts (carnallite, $MgCl_2 \cdot KCl \cdot 6H_2O$ en bischofite, $MgCl_2 \cdot 6H_2O$ )
	Andydrite ( $CaSO_4$ )

# Solution mining of pure $MgCl_2$ (bischofite)

- From the Zechstein III 1b layer, with varying structure and on average about 15% bischofite
- Bischofite can be a flat thin layer, an ingredient in a hotchpotch of salts, or anything in between
- Bischofite dissolves best and can selectively be leached: Nedmag mines “the red sauce from the lasagna”
- The caverns have the labyrinth like shape of the dissolved salt. They are not traditional caverns



# Veendam pillow and wells



- 15 wells of which 2 out of use, plus 2 planned
- Over time, 9 caverns became interconnected, forming the so called TR-cluster

# Switch from hard shut in to bleed off first

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- 7 years ago, at Nedmag, “*cavern*” abandonment was foreseen via hard shut in
- In 2018, despite sublithostatic cavern pressure, a frac in the salt roof of one of Nedmag’s caverns occurred
- Cause: cavern pressure exceeded the salt roof stress
  - During prolonged periods of sublithostatic cavern pressures, the salt roof stress decreased significantly, due to stress arching in overburden (vertical stresses decrease and salt stresses follow)
- After abandonment, cavern pressures rise and new fracs will likely occur. The associated risks have to be acceptable -> **pre-abandonment bleed off**

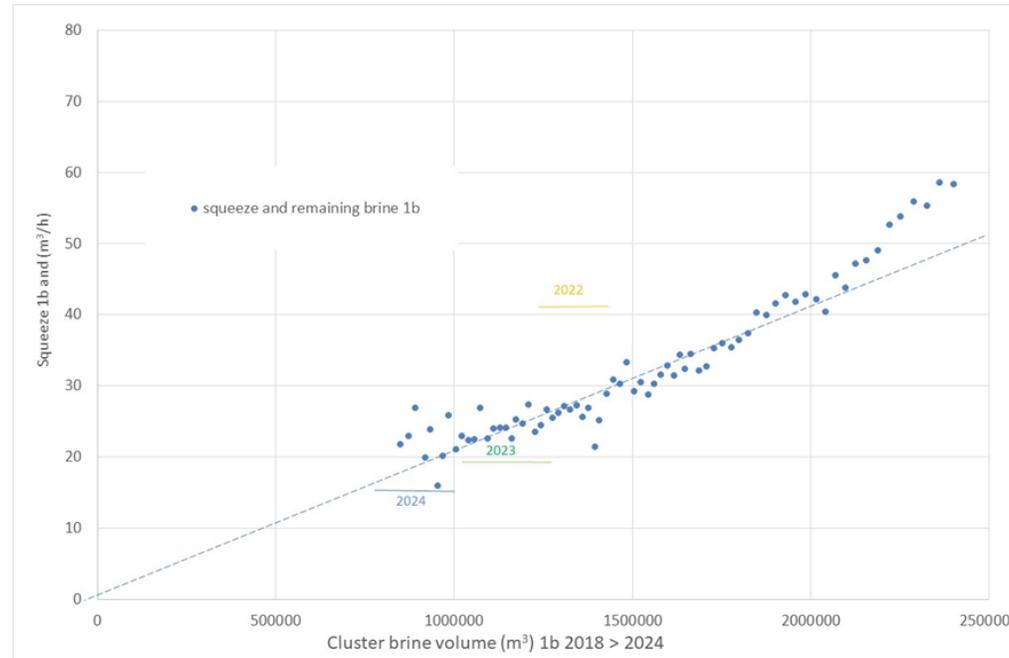
# Pre-abandonment bleed off

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- @ Nedmag, a pre-abandonment bleed off at sublithostatic pressure is possible as the caverns converge rapidly
- The rapid convergence is due to the combination of
  - Cavern shape (thin with large lateral dimensions)
  - Salt properties (bischofite and carnallite creep fast)
  - Cavern temperature (about 70°C)
- The advantages of a pre-abandonment bleed off are clear:
  - Limited remaining volumes, resulting in minimum post-abandonment risks
    - In case of a frac, fluid outflow out of a small cavern is much smaller than out of a large cavern
  - Minimisation of post-abandonment soil subsidence
    - Dealing with subsidence is not passed on to future generations

# Experience with TR-cluster bleed off

- The TR-cluster is Nedmag's largest cavern
- The cluster is being bled off at constant pressure since June 2018
  - Without anomalies
- Convergence and subsidence linear with remaining open brine volume



- End of bleed off expected around 2045