



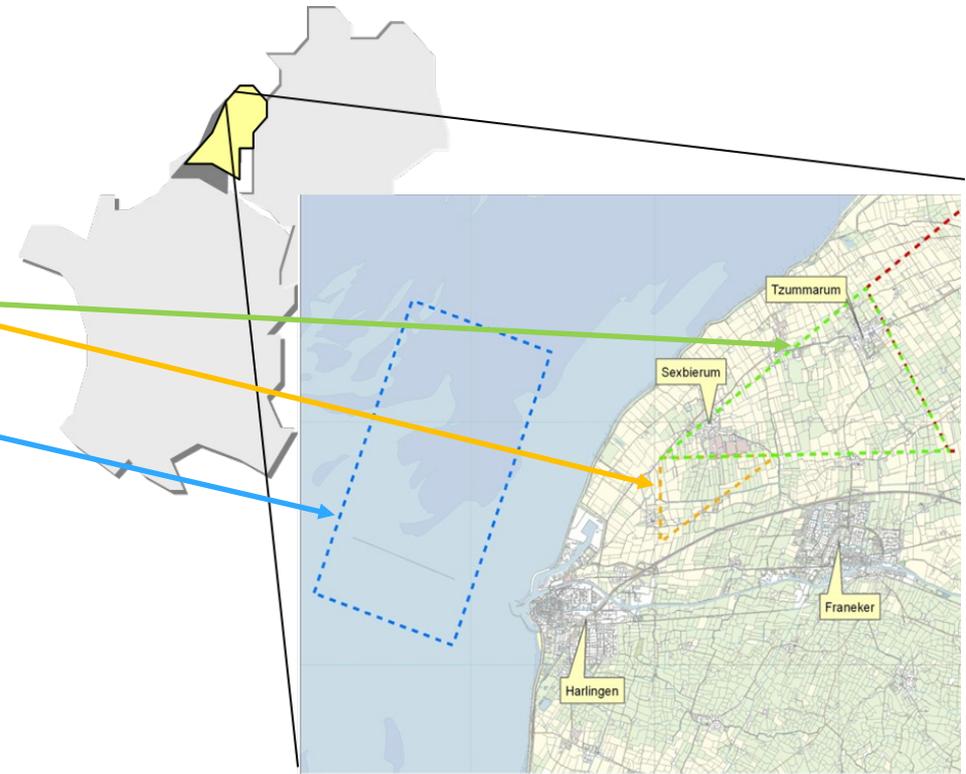
11-11-2019      Bart Hendriks, Technical Director Frisia Zout B.V.

## **Operators perspective on abandonment: Barradeel experience**

# Frisia Zout B.V. Harlingen



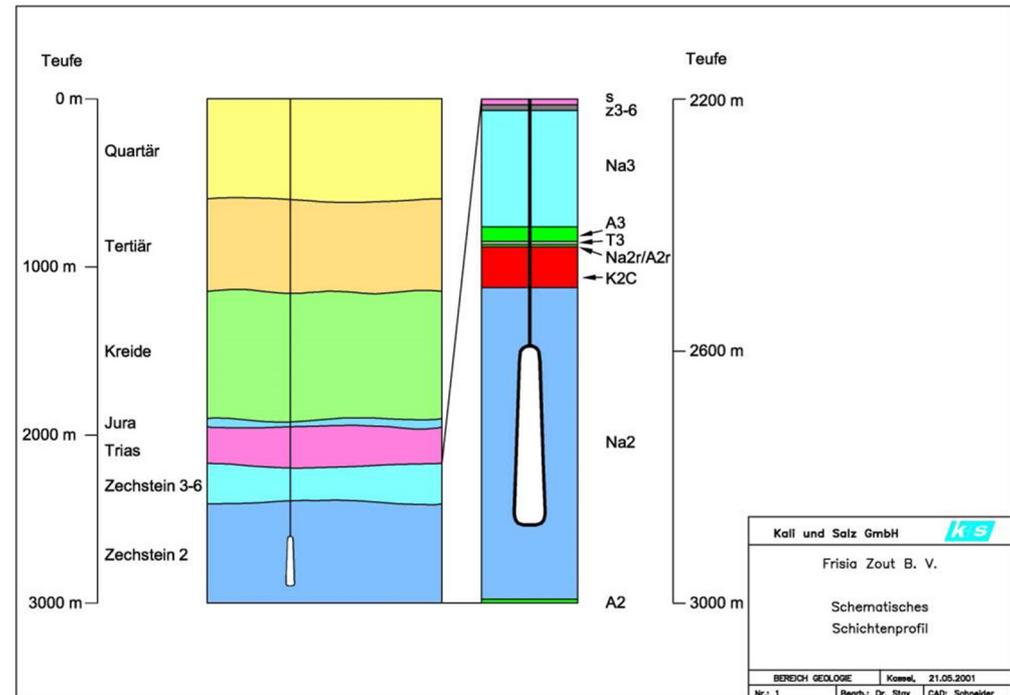
- Frisia Zout BV manufactures high grade vacuum salt since 1996
- Since 2000 part of the K+S group
- Located at the sea harbour of Harlingen
- Three concession area's
  - Barradeel
  - Barradeel II
  - Havenmond
- Five caverns
  - BAS 1: inactive
  - BAS 2: abandoned
  - BAS 3: abandoned
  - BAS 3O: partially abandoned
  - BAS 4: active



# Solution mining characteristics



- Solution mining in Zechstein 2
- Medium size caverns
  - 0.3 – 1.0 mio m<sup>3</sup>
- Very deep caverns
- Very high creep
- Strong convergence
- Subsidence limited



# Typical well design

- Large bore casing
- Last cemented casing shoe (14") below Carnalite layer
- Dual concentric productions completions: 7" and 11<sup>3</sup>/<sub>4</sub>"
- Top and bottom injection possible and practised



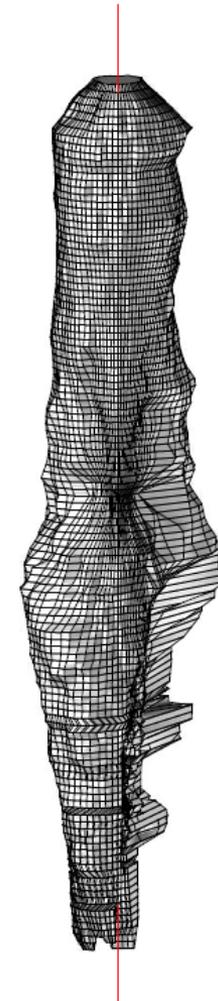
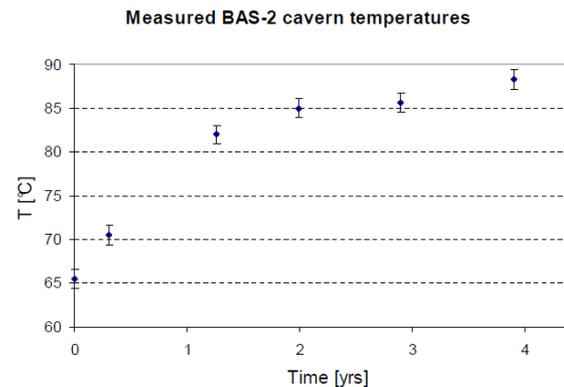
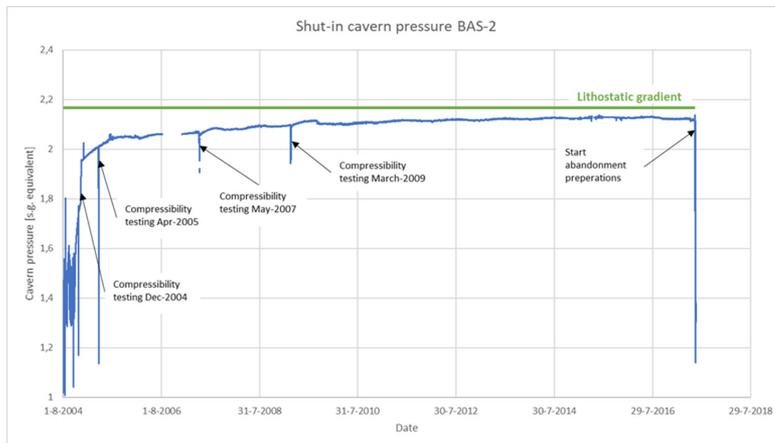
Nr.	Item Description	Wellhead and Xmastree BAS 4		Depth	Depth	Hole ID	Pipe	Collar	Pipe ID
		m	m	in	OD	OD	in	in	
		ftd	ah						
2A	28" x 1" X 52E conductor shoe			14,5	14,5	driven	28,000	welded	28,000
2	24" x 1/2" WT 35 ksi conductor, welded				279	26	24,000	welded	23,000
	7" wireline profile 5.75 Otis 'R'			527	527	*estimated			
3	Top cement in 18 5/8 " x 13 3/8" annulus			916	916				
4	18 5/8" 87.5 ppf K55 Big Omega casing			1126	1126	22	18,625	20,000	17,688
6	13 3/8" 68 ppf P110 VAM-TOP casing			1980	1980	16	13,375	14,375	12,415
	Bottom carnalite			2382	2382				
7	14" heavy wall 106 ppf N80			2410	2410	16	14,000	14,000	12,500
	Diesel depth December 2007			2590	2590				
	11 3/4" 65 ppf VM 80 HC, VAM FJL outer leaching string, internally coated			2600	2600	17 1/2"	11,750	11,965	10,682
	7" 26 ppf N80 VAM TOP inner leaching string, internally coated			2735	2735	17 1/2"	7,000	7,375	6,276
	Estimated sump level March 2008			2745	2745				
	Total Depth Cavern				2810				

\* All depths are from ground level

# Case study: BAS-2



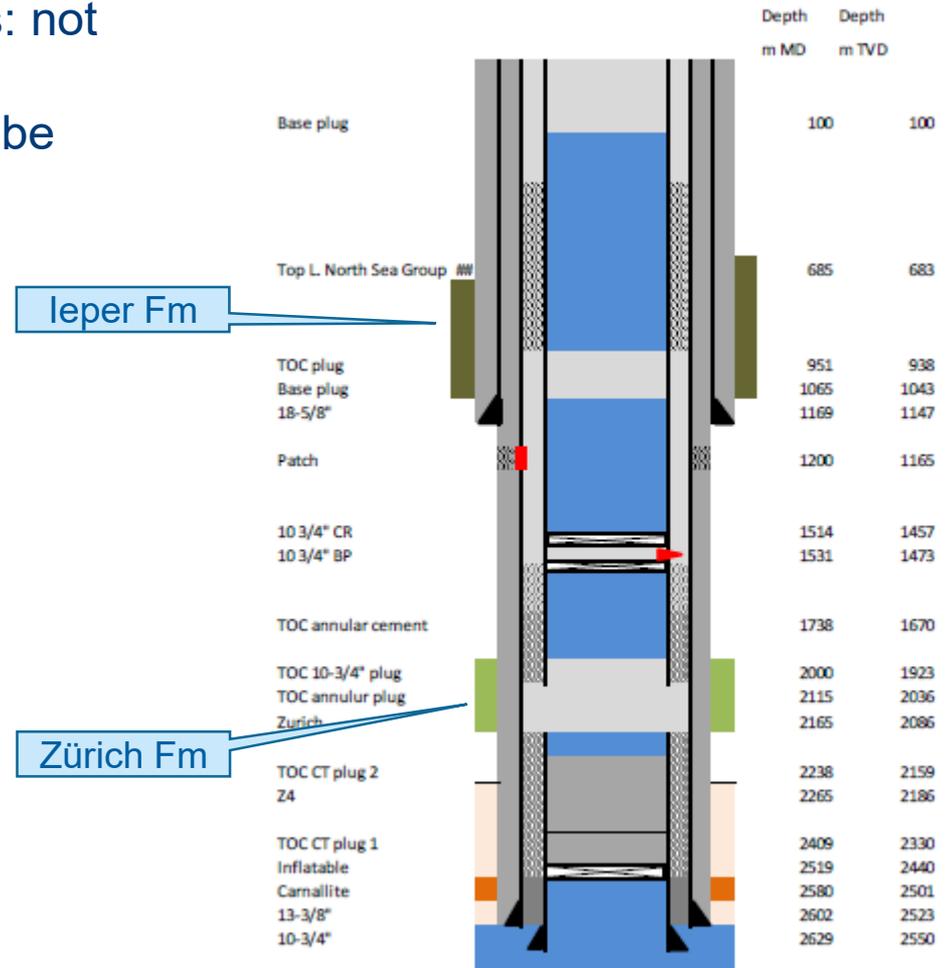
- Cavern drilled in 1995
- Production stopped in 2004
- Annular top down cementation 2003
- Long term observation period 2003-2017
  - Temperature increase as expected
  - Pressure increase to just under lithostatic pressure
  - A higher pressure was expected due to thermal expansion
  - Implicates: gradual permeation



# BAS-2 abandonment in practice



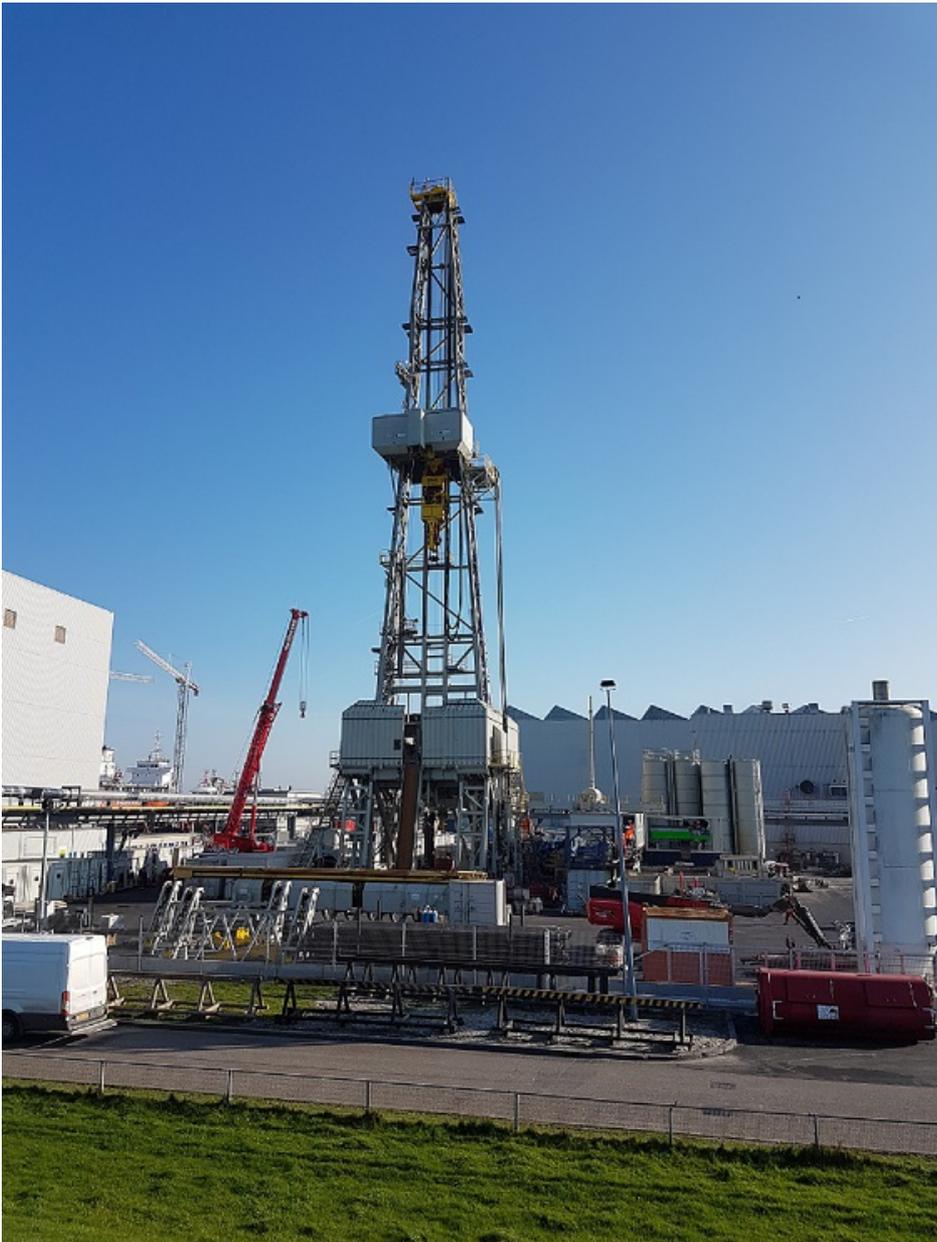
- First plug placed accross the top of the Zechstein
  - Permeation model implicates: not sealing
- Mining law requirement: Plugs to be set across sealing formations
- First sealing formation: Zürich formation
  - Placement of primary abandonment plug
- Second sealing formation: Ieper formation
  - Placement of secondary abandonment plug
- Final plug: environmental plug



# Barradeel caverns abandonment: conclusions and observations



- Frisia has abandoned two wells and partially abandoned one
- Each well posed its own challenges in the practice of abandonment
- Close alignment with authorities (SodM) is indispensable
- Principle of plugging across a sealing layer was achieved
- Generic abandonment design based on legal requirements possible
- Actual abandonment design will be different for each well due to specific circumstances



Drilling of 1<sup>st</sup>  
Havenmond well  
has started

Frisia Zout B.V.