



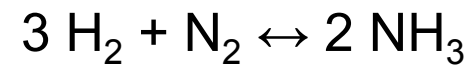
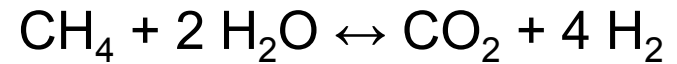
## Storage of CO<sub>2</sub> in Limburg Coal and Sandstone Layers Project



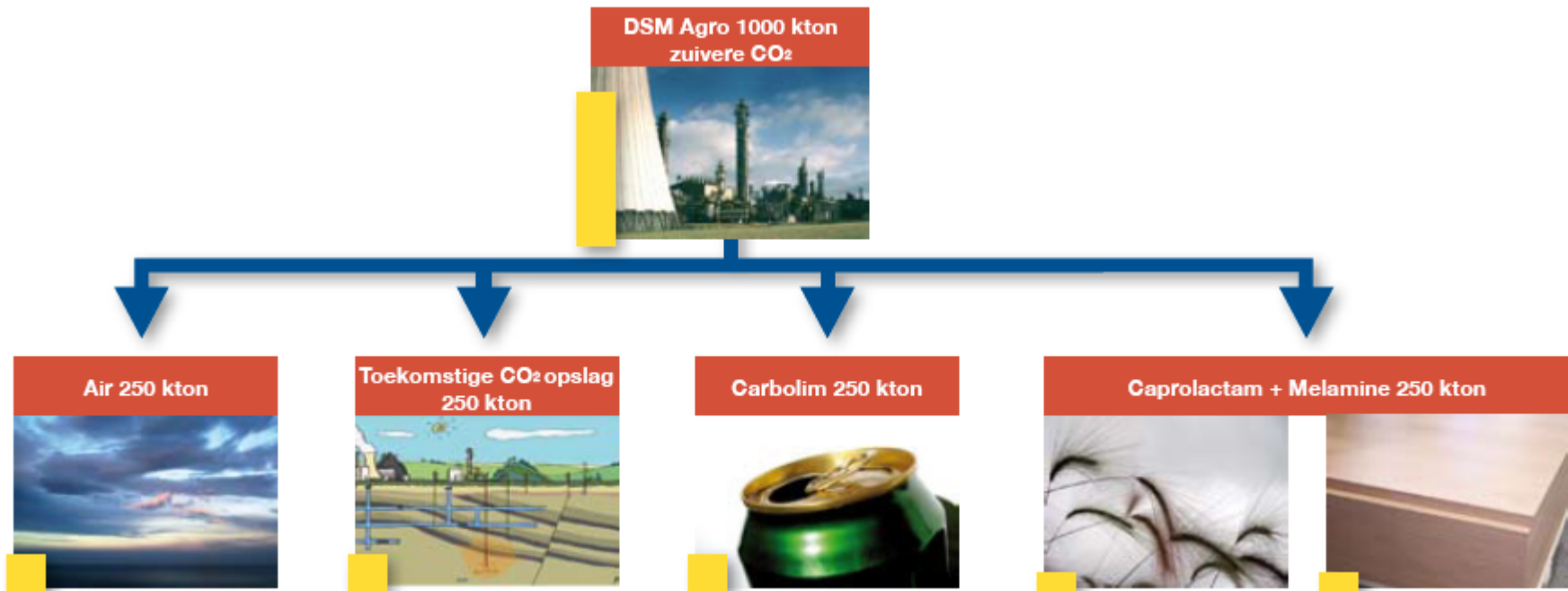


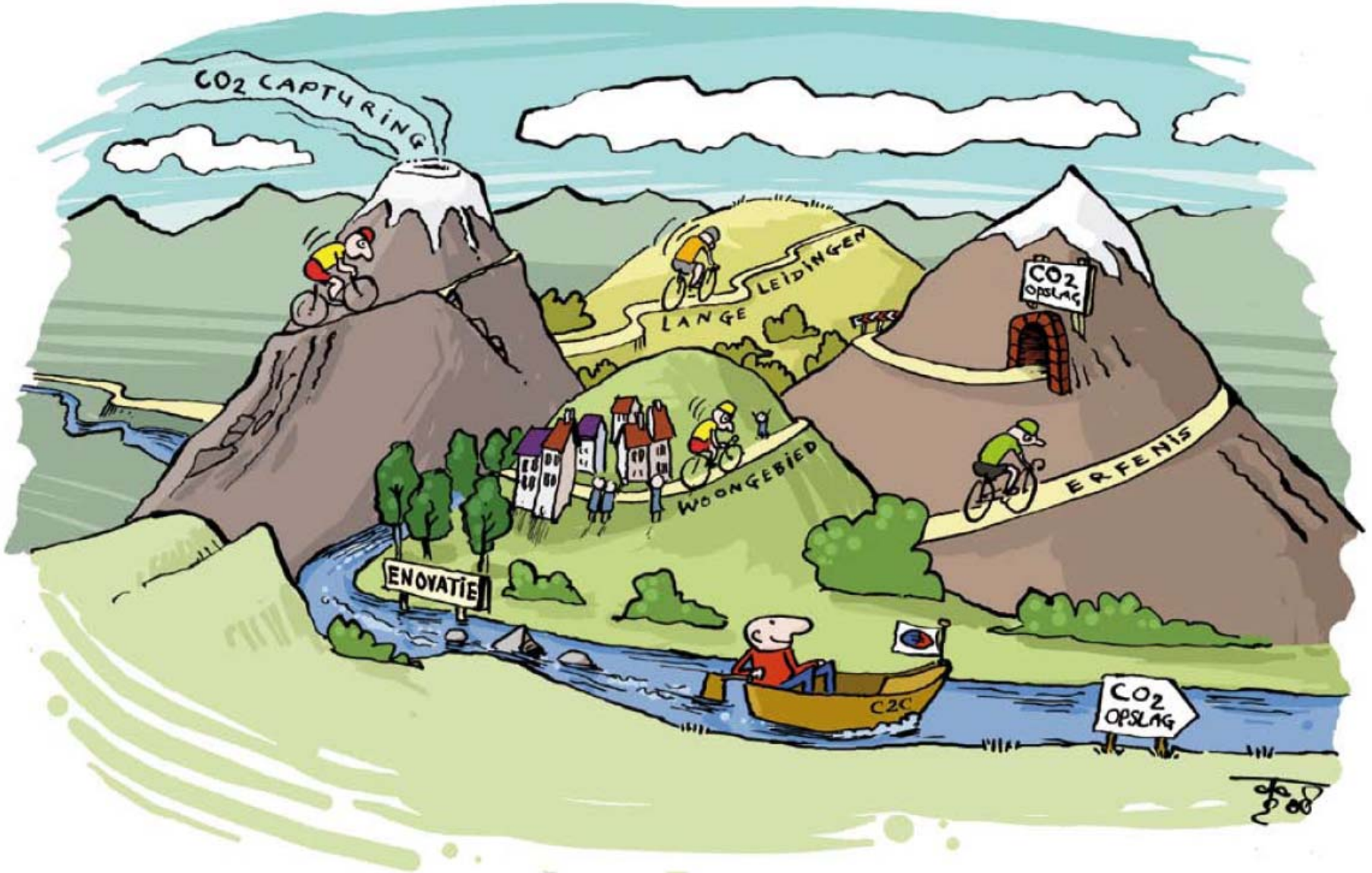
# Amount and quality of CO<sub>2</sub>

- » 1.000 kTon/y
- » Pressure: 1,4 – 1,6 bar
- » Temperature: 10 – 35°C
- » Purity:  $\geq 99\%$ 
  - » H<sub>2</sub>: 0,30%
  - » N<sub>2</sub>: 0,20%
  - » hydrocarbons: 30 – 600 ppm(v)
  - » methonal: 50 – 500 ppm(v)
  - » CO: 6 – 50 ppm(v)
  - » O<sub>2</sub>: < 1 ppm(v)
  - » NH<sub>3</sub>: < 1 ppm(v)
  - » H<sub>2</sub>O: 7 – 25 g/Nm<sup>3</sup>



# Distribution of the process CO<sub>2</sub>





# Deep aquifers

- » Potential reservoir levels
  - » Cretaceous chalks
  - » Triassic sandstones
  - » Westfaliaan sandstones
  - » Carboniferous limestones
  - » Devonian limestones
- » (Relatively) small traps
- » Large uncertainty
- » Need for exploration



# Coal bearing strata

- » Aquifer-type storage
- » Chemical trapping
  - » on coal
  - » on claystones
  - » mineral trapping
- » Capacity  $\geq 400 \times 10^6$  ton
- » Low injection rates
- » Experimental phase
- » Co-production of CBM



# Storage concept

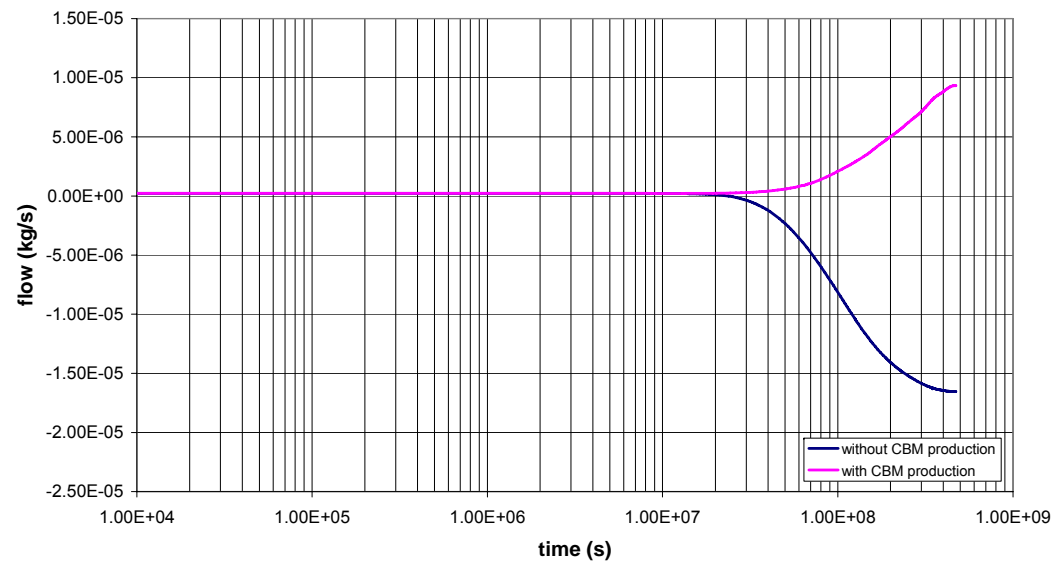
- » Experience
  - » Alison unit – San Juan Basin
  - » Fenn Big Valley – Alberta
  - » JCOP – Ishikari (Hokkaido)
  - » RECOPOL – Silesian Coal Basin
  - » South Qinshui Basin (Shanxi)
- » Low injectivity
  - » 5 – 15 kton/y per well
- » Limited storage capacity
- » Impact on CBM-production unclear
- » Focus on CO<sub>2</sub>-storage
- » Increase injectivity
  - » 50 – 70 ton/y per well
- » Control flow
- » Prerequisites
  - » alternation of sandstone and coal layers
  - » large chemical trapping potential (coal and sandstones)
  - » suitable permeability window
  - » adequate vertical sealing
  - » no or limited tectonic disturbance



# Containment concept

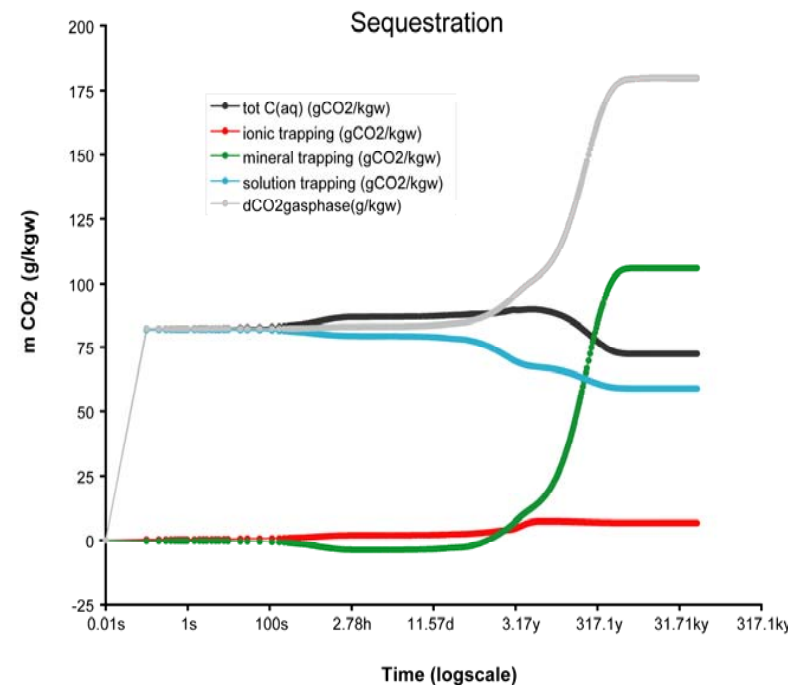
- » During injection phase
  - » overlying Westphalian strata
  - » low permeability of injection layers
  - » control of flow by pressure differences

Flow Wilhelmina subcrop (@3500m)



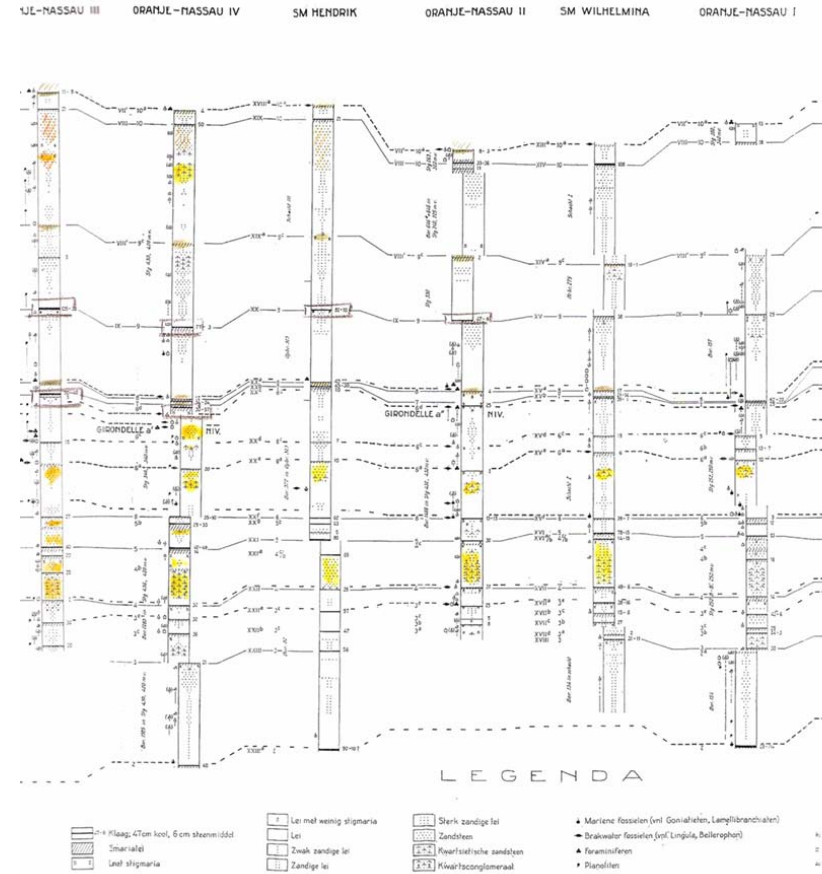
# Containment concept

- » During injection phase
  - » overlying Westphalian strata
  - » low permeability of injection layers
  - » control of flow by pressure differences
- » After injection phase
  - » dissolution and dissociation
  - » adsorption on coals ( $55 \text{ kg/m}^3$ )
  - » adsorption on carbonaceous shales ( $3 - 5 \text{ kg/m}^3$ )
  - » mineral trapping ( $12 \text{ kg/m}^3$  for Westphalian sandstones)



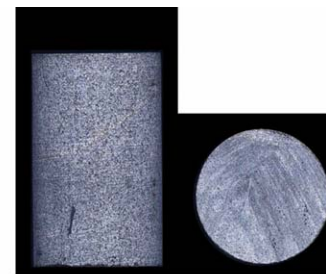
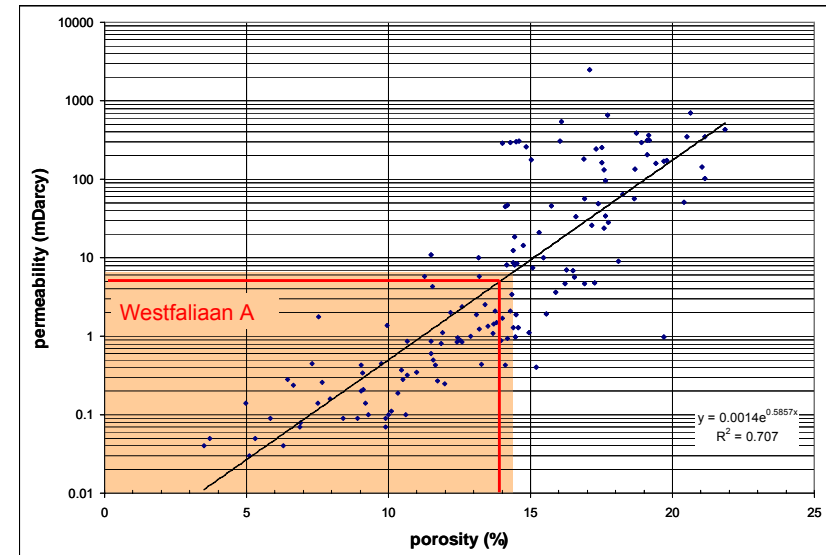
# Site selection

- » Lithological succession
  - » mining archives and coal exploration wells
  - » Lower Westpalian A strata

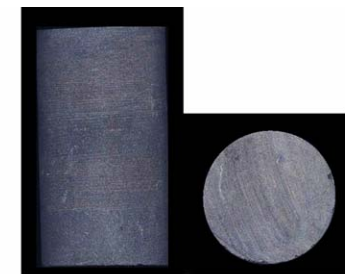


# Site selection

- » Lithological succession
  - » mining archives and coal exploration wells
  - » Lower Westpalian A strata
- » Evaluation of permeability
  - » core samples exploration wells
  - » water inflow former mines
  - » outcrops



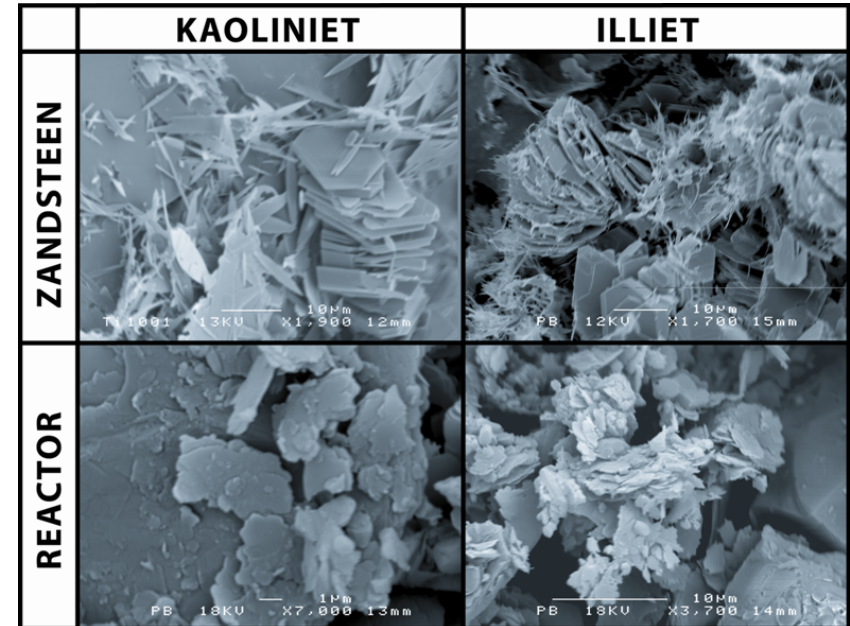
Sample: 1



Sample: 2

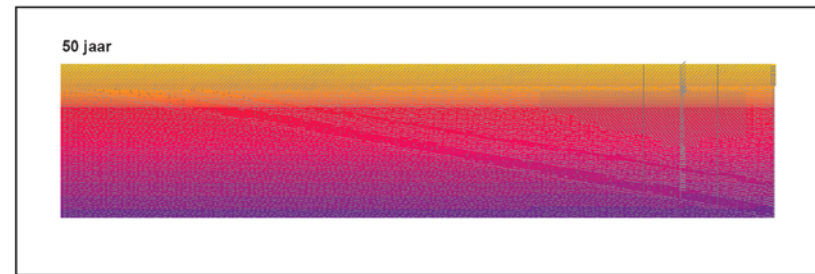
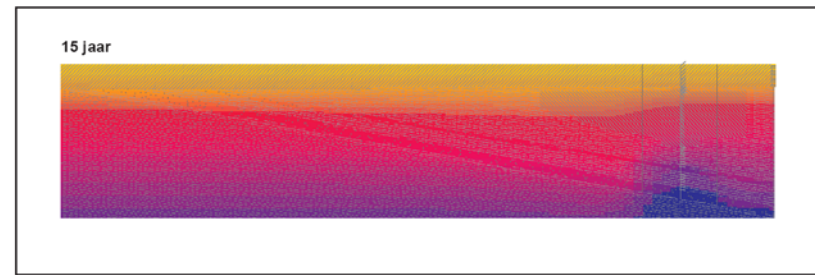
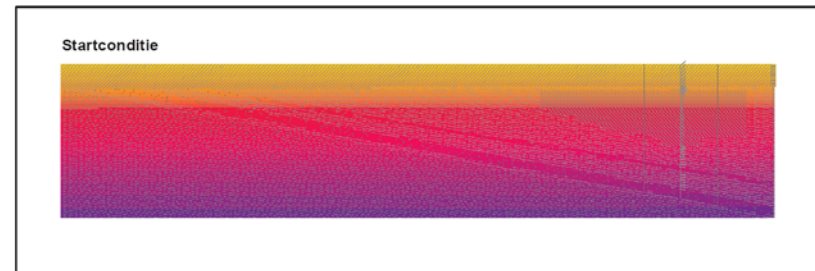
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  - » outcrops
- » Evaluation of chemical trapping
  - » adsorption tests
  - » batch reaction tests

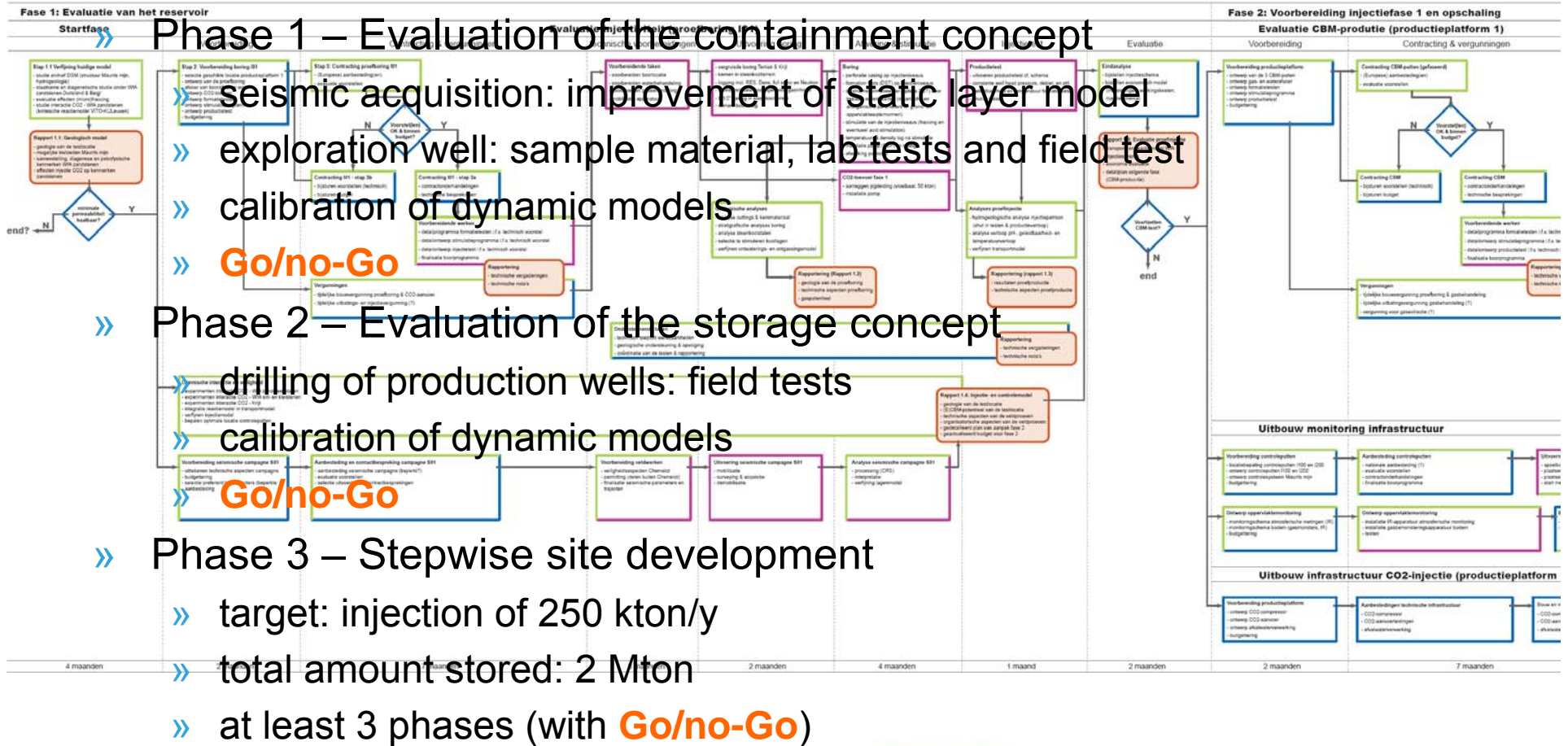


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- » Evaluation of chemical trapping
  - » adsorption tests
  - » batch reaction tests
- » Flow and chemical modelling



# Project set-up



# Learning effects

- » Close collaboration with stakeholders
  - » legal issues and regulation: EZ, SenterNovem, province, local authorities
  - » public: community meetings, local committees, media
  - » scientists: CATO2, PSS-CCS II, EU R&D programs, special tests, new monitoring techniques, second opinions
- » Knowledge dissemination
  - » official reports, publications, presentations and press
  - » collaboration in research projects (e.g., CATO2, PSS-CCS II)
- » Relevance for other regions
  - » coal basins in the Netherlands and abroad
  - » new local storage option for small to medium CO<sub>2</sub> sources





Questions?