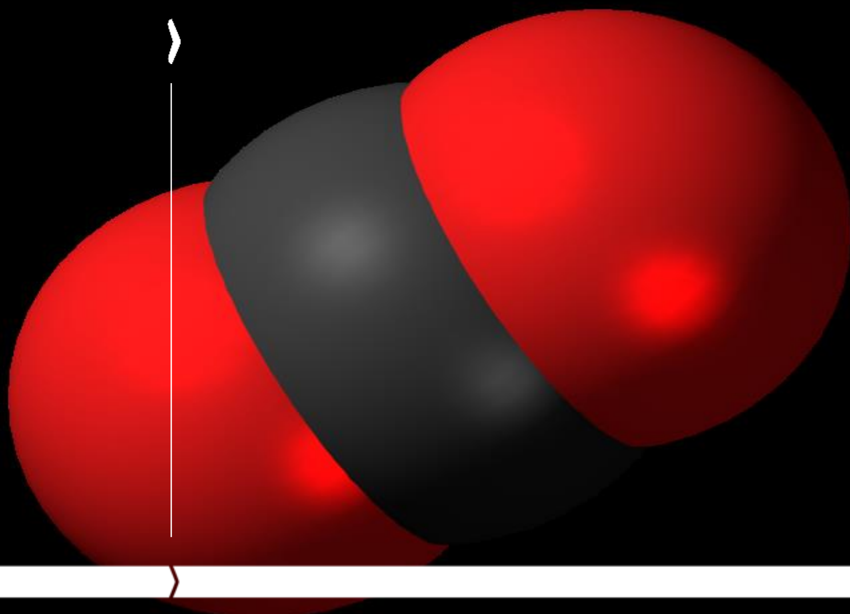
EFFECTS OF SO_2 CO-INJECTION ON CO_2 STORAGE

KOENEN, M.*, WALDMANN, S., HOFSTEE, C. AND NEELE, F.



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MARIELLE.KOENEN@TNO.NL

RATIONALE IMPACTS PROJECT

- Investigate relation between impurities and design / performance of CCS chain
- Because:
    - Impurities in the CO_2 stream are costly and energy-intensive to remove

  but

    - Adapting the transport and storage infrastructure to handle impurities can also be expensive

- Provide knowledge base for defining maximum tolerable impurities

INTRODUCTION

- From geochemical point of view SO_2 is one of the most important impurities for storage

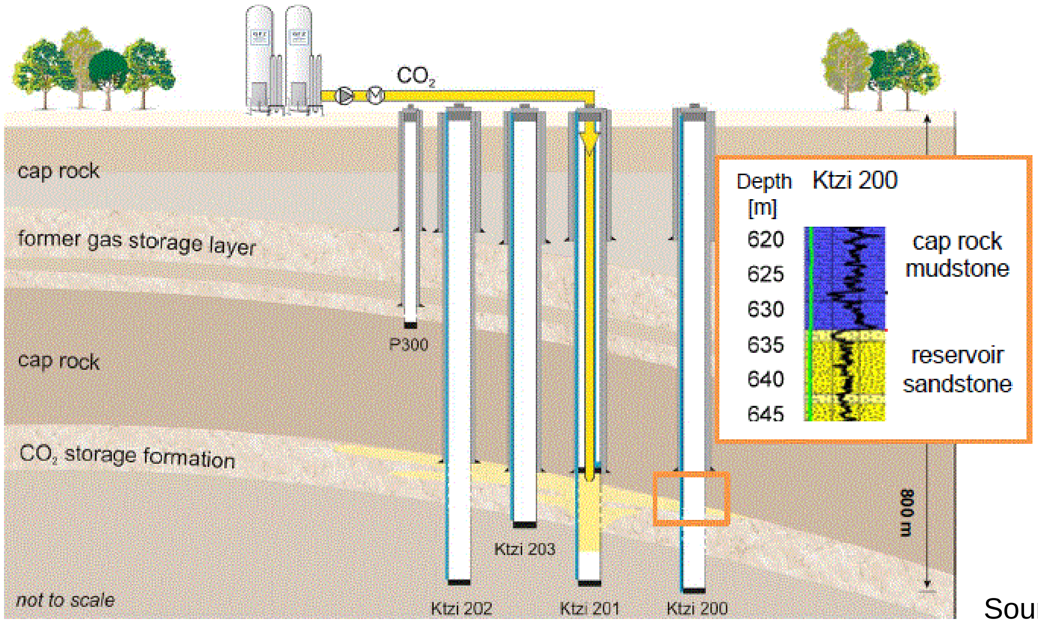
- Aim:
- Investigate whether SO_2 co-injection on CO_2 storage is positive or negative for:
  - **Injectivity** and **storage capacity**: porosity changes in reservoir during injection phase
  - **Sealing integrity**: long-term reactivity of caprock and wellbore cement

- Consider potential additional costs to allow SO_2 in the CO_2 stream

- Tool: Geochemical modelling with *PHREEQC*

CASE STUDY: INSPIRED BY KETZIN, GERMANY

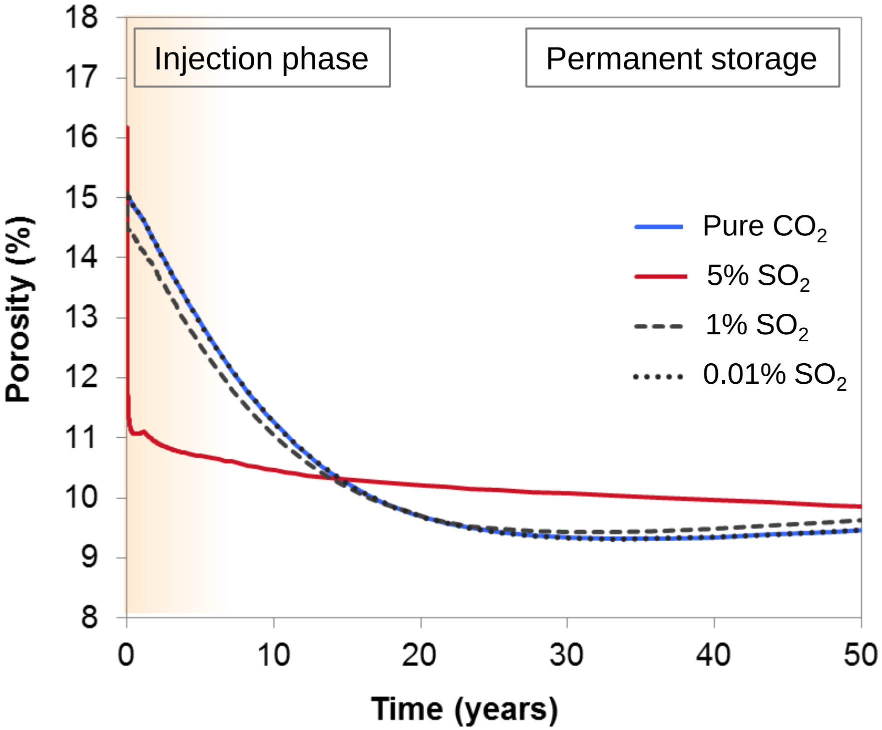
- Saline aquifer structure at relatively shallow depth (P - 8 MPa; T - 33°C)
- Sandstone reservoir and shale caprock
- Wellbore Portland cement
- Consistent with experimental study in project: 5% co-injection of SO_2



Source: GFZ

IMPACT OF SO_2 ON INJECTIVITY

SHORT-TERM POROSITY CHANGES IN RESERVOIR



- Kinetic batch model
  - Fluid-rock interactions with time
  - Corresponding porosity changes

Results

- At 5% SO_2 (compared to pure CO_2):
  - Large pH reduction
  - Faster mineral reactions
  - Faster porosity reduction

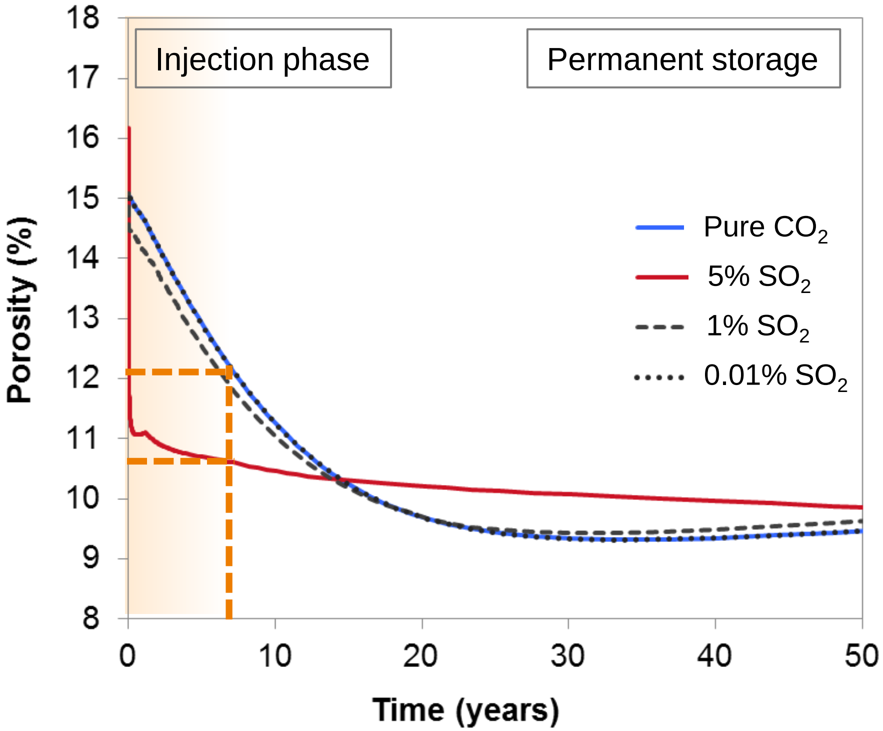
- At *realistic* SO_2 concentrations, porosity evolution similar to pure CO_2

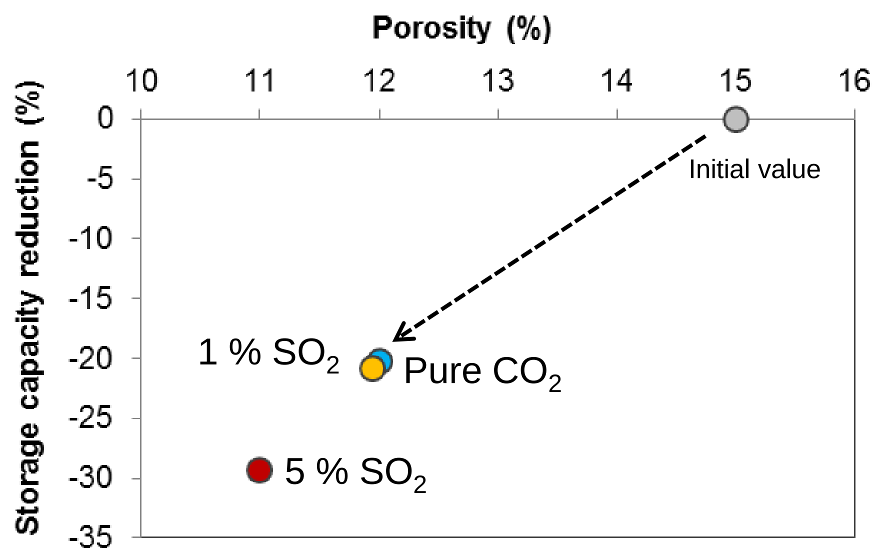
IMPACT OF SO_2 ON STORAGE CAPACITY

SHORT-TERM POROSITY CHANGES IN RESERVOIR

- Porosity changes during injection phase could affect volume for CO_2 storage
- Example: porosity reduction after 7 years of injection

Large capacity reductions: 20-30%





IMPLICATIONS FOR CO_2 STORAGE

Injectivity and storage capacity

- Fluid-rock interactions caused by the injection of (impure) CO_2 affect porosity
- Regardless of SO_2
- Potential injectivity issues and reduction of storage capacity

- At *high* SO_2 concentrations injectivity issues and storage capacity reduction could be enhanced

✓ At *realistic* SO_2 concentrations, these effects are negligible

IMPACT OF SO_2 ON SEALING INTEGRITY

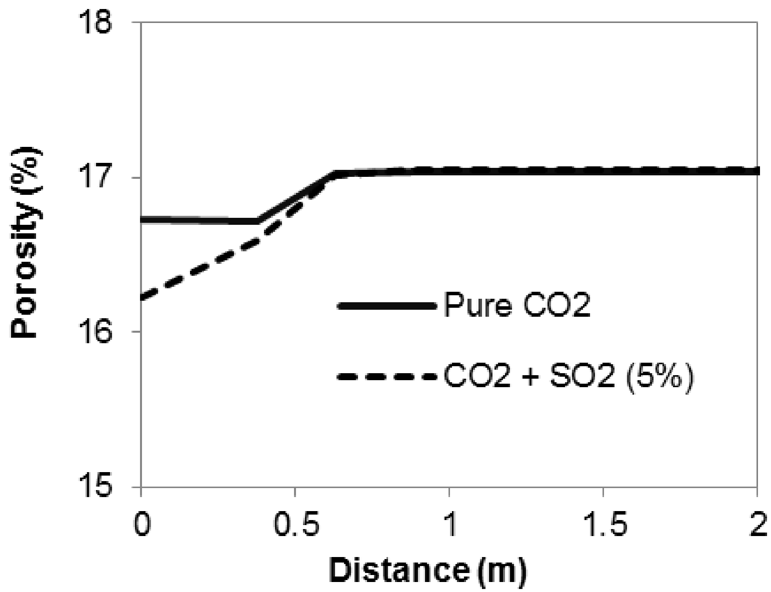
CAPROCK

- 1D reactive transport model:
- Diffusion of dissolved CO_2 and SO_2 into the caprock
- Fluid-rock interactions with time as a function of distance from reservoir
- Corresponding porosity changes

Results

- Mineral reactions similar to reservoir
- After 200 years, only bottom few decimeters affected
- Enhanced porosity decrease

After 200 years



IMPLICATIONS FOR CO_2 STORAGE

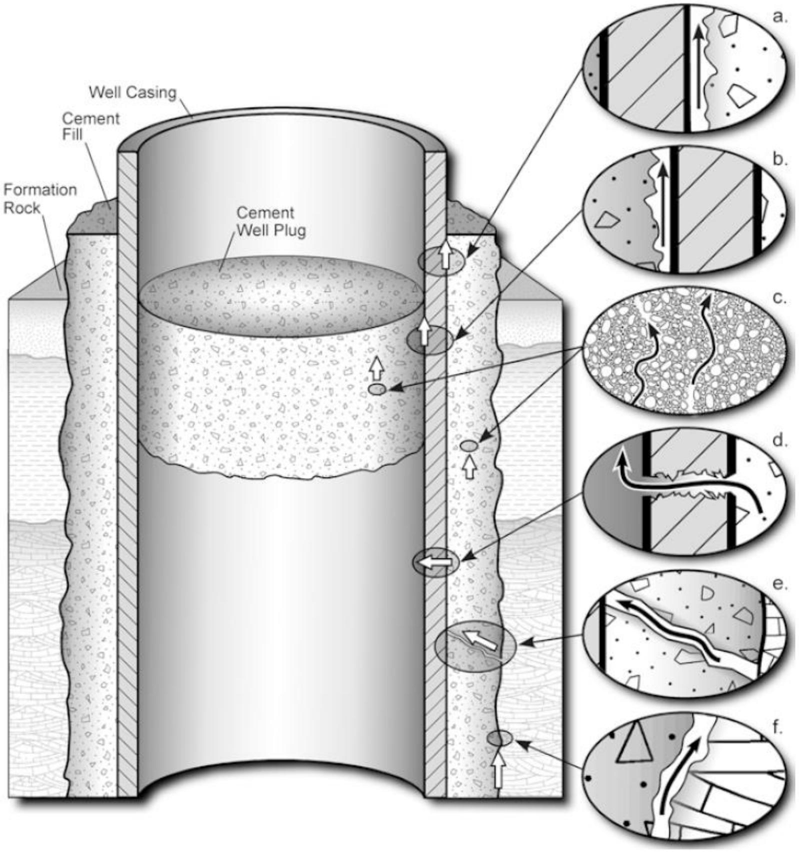
- **Long-term caprock integrity**

- Porosity decrease is favorable for sealing
- Sealing integrity is enhanced by the presence of SO_2

IMPACT OF SO_2 ON SEALING INTEGRITY
WELLBORE CEMENT

- Annular cement is primary seal

- 1D reactive transport model:
  - Diffusion of dissolved CO_2 and SO_2 into the cement
  - Fluid-rock interactions with time as a function of distance from reservoir
  - Corresponding porosity changes



From Gasda et al. (2004)

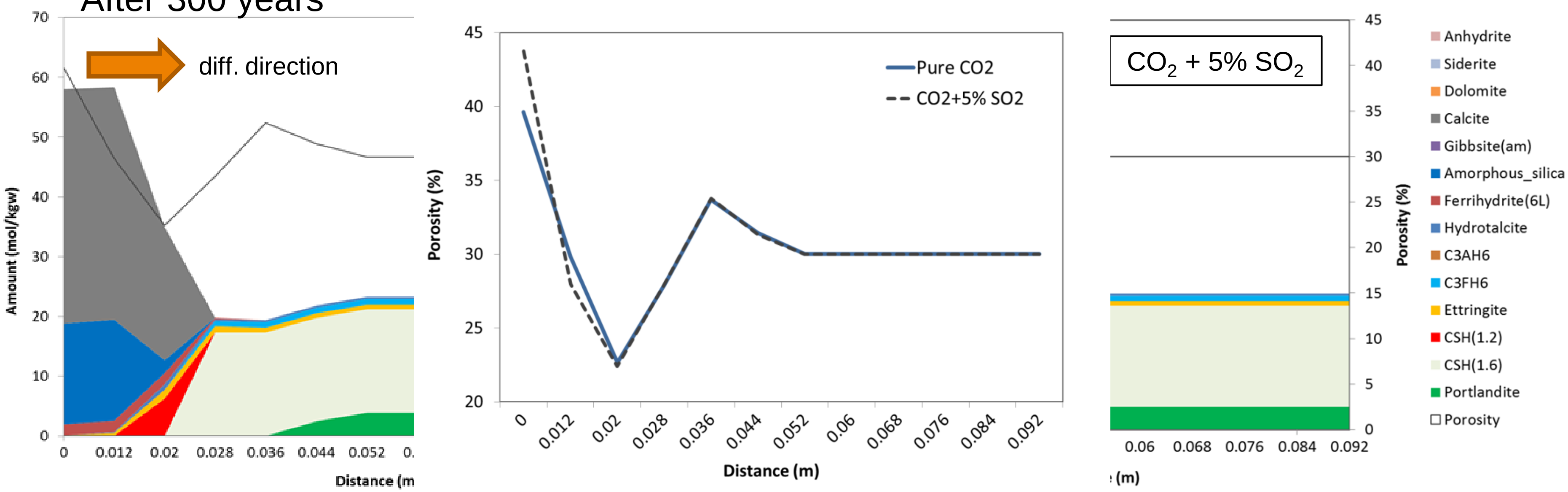
IMPACT OF SO_2 ON SEALING INTEGRITY

WELLBORE CEMENT

Results

- Cement minerals unstable in acid environment
- Complete alteration of mineralogy; various reaction zones
- Inward progression of zones with continuous diffusion of dissolved CO_2 and SO_2
- Additional effect of SO_2 negligible, even at high concentrations

After 300 years



IMPLICATIONS FOR CO_2 STORAGE

› **Long-term cement sealing integrity**

- Wellbore cement integrity deteriorates in the presence of CO_2
- Regardless of the presence of high concentrations of SO_2

➢ Wellbore sealing by annular cement could be a serious issue
➢ Options: additional leakage monitoring, innovative abandonment procedures or use of different materials

CONCLUSIONS

- High levels of SO_2 (5%) in the CO_2 stream can:
  - cause (additional) injectivity issues
  - increase reduction of storage capacity
  - slightly enhance deterioration of wellbore cement

- Caprock sealing issues are not expected

- **BUT!**
- At SO_2 concentrations < 1% the effects are very similar to a pure CO_2 stream
- No additional effects, and hence costs, are expected if SO_2 remains in the CO_2 stream!

THANK YOU FOR YOUR ATTENTION

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