ACT-CCS project

Cementegrity

Development and testing of novel cement designs for enhanced CCS well integrity

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Main motivation

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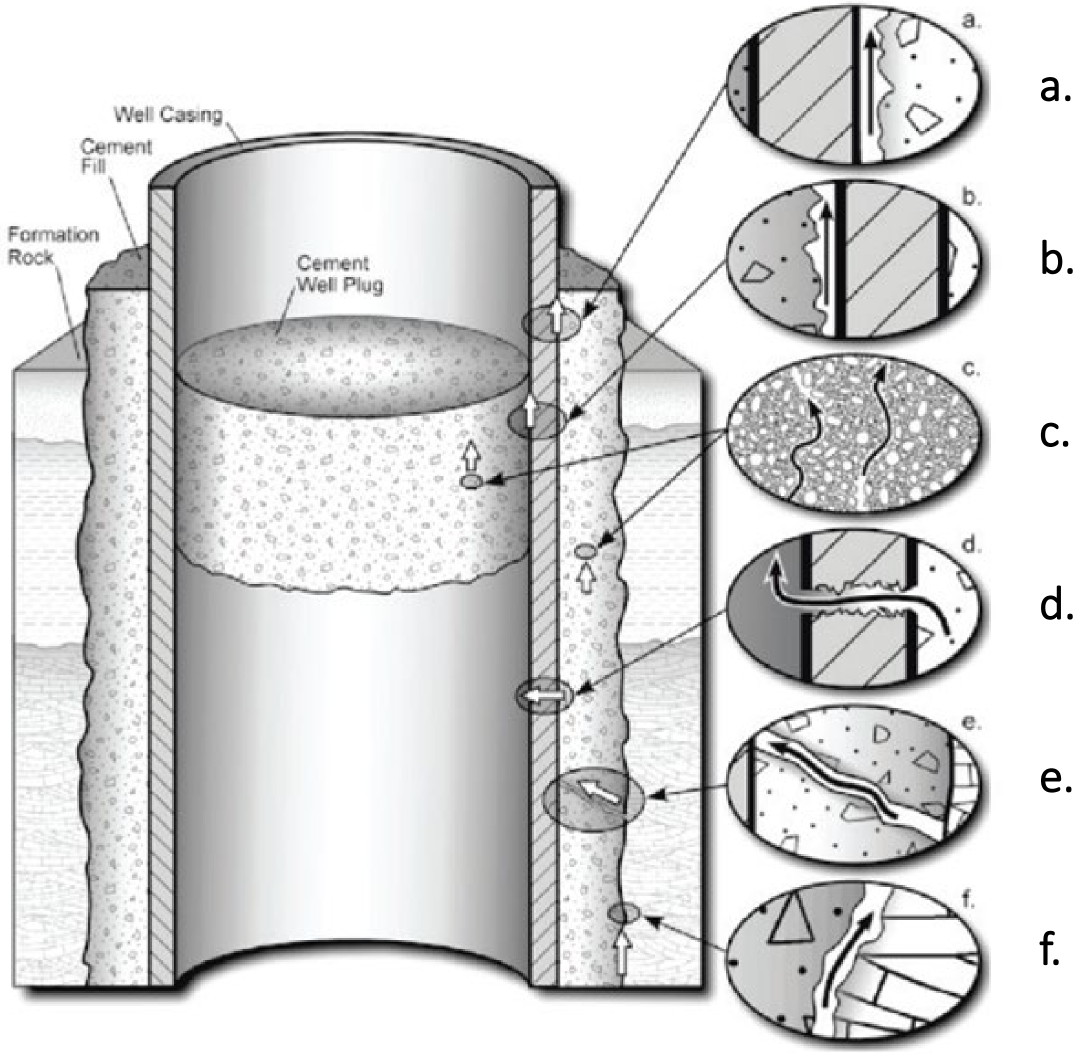
- How can we ensure wellbore seal integrity over the full duration of CO_2-storage?
- Cement seal identified as important potential weakness in the system
- Priority Research direction S9 (PRD S-9) asks for experiments simulating well leakage:
  1. Fluid flow
  2. Mechanical stresses and their effects on interfaces
  3. Chemical reactions
  4. Impurities in CO_2 and water
  5. Self-healing vs. self-enhancing leakage behaviour

Wellbore leakage pathways

- During emplacement, or
- During subsequent operation

- Along interfaces (a, b, f)
- Along fractures (d, e)
- Through the cement body (c)

- Weakening due to chemical, mechanical and thermal effects



Schematic illustration of a plugged wellbore, showing potential leakage pathways.

From: Celia et al. (2005) Quantitative estimation of CO2 leakage from geological storage: Analytical models, numerical models, and data needs. GGCT1, 663-671.

Partners

CEMENTEGRITY

IFE

HALLIBURTON

TU Delft
Delft University of Technology

Universitetet i Stavanger

ebn

HERIOT WATT UNIVERSITY

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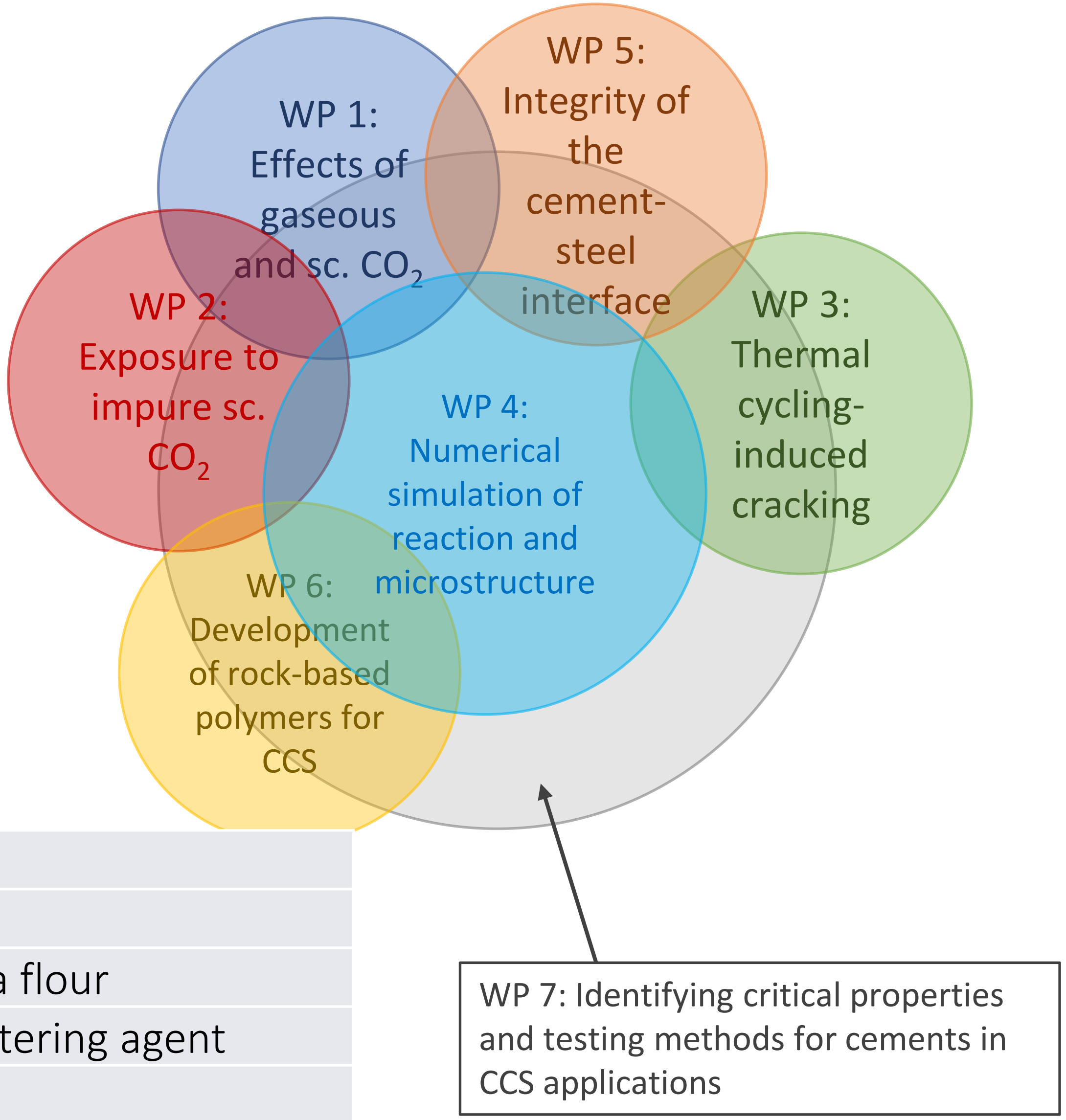
Project structure

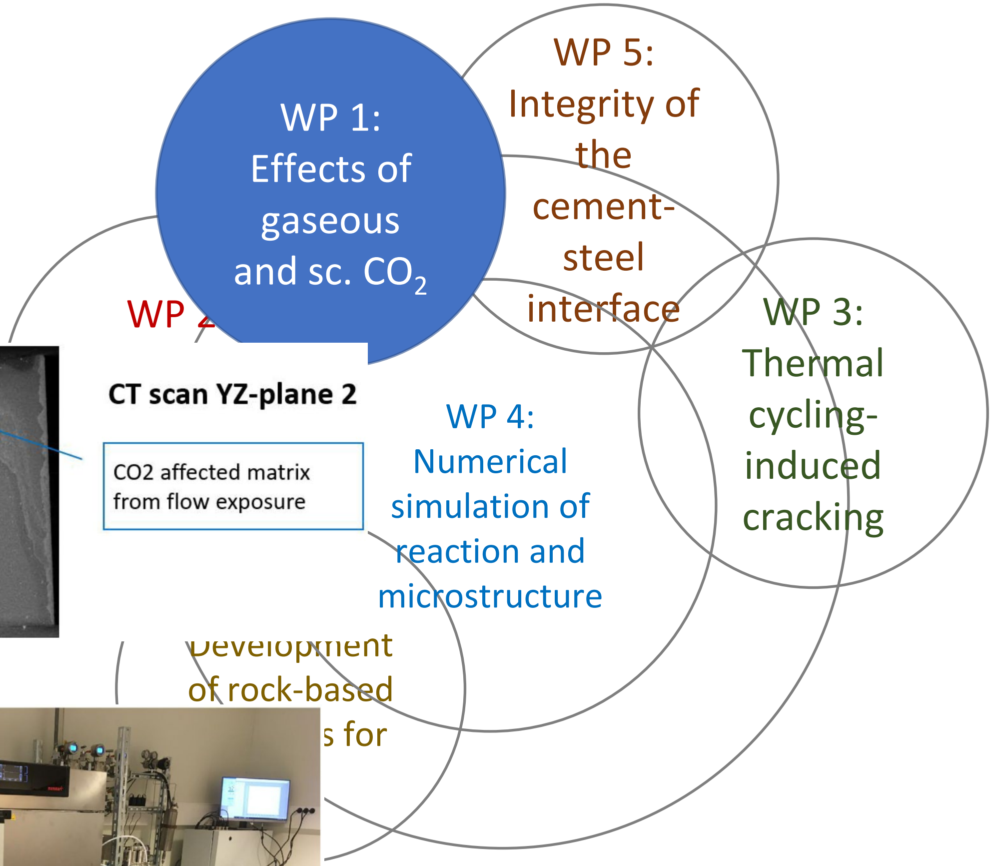
- Seven WPs in addition to administration (IFE)
- Close cooperation: Will have interactions between partners and across WPs
- **Sample compositions and preparation**
- Central preparation of samples for all WPs by Halliburton
- Samples cured under water, at 150 °C and 30 MPa for 28 days to ensure full hydration

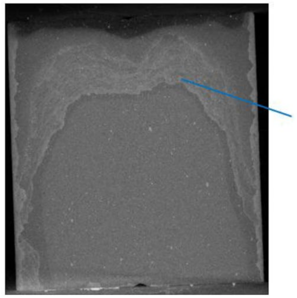


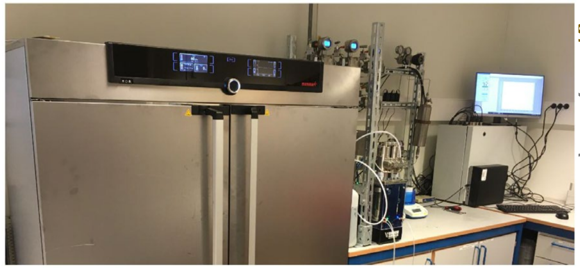
Five sealants selected for testing
1,92 SG class G cement with 35% BWOC silica flour
1,90 SG ultra low permeability class G cement with 35% BWOC silica flour
1,90 SG class G cement with 35% BWOC silica flour and CO2 sequestering agent
1,80 SG blend based on calcium aluminate
Geopolymer based on feldspar-rich rock material

WP1 Effects of gaseous and supercritical CO_2

- Led by Halliburton
- Flow-through exposure of selected cement compositions to gaseous and supercritical CO_2
- Measuring development of permeability and mechanical properties (Young's modulus, strength)
- Using micro-indentations to measure distribution of mechanical properties after exposure







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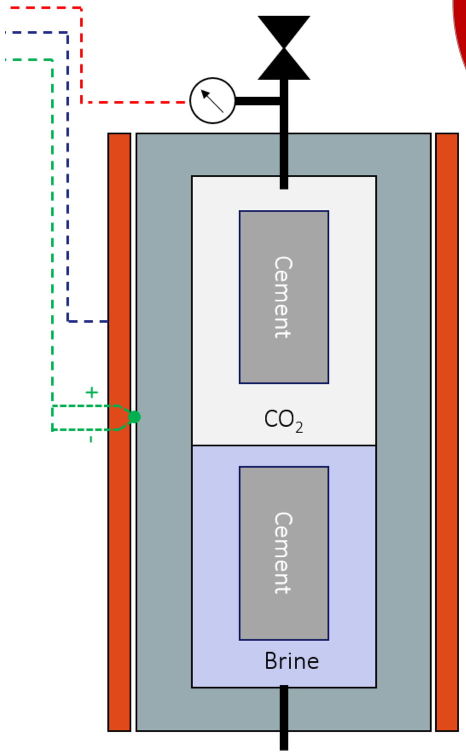
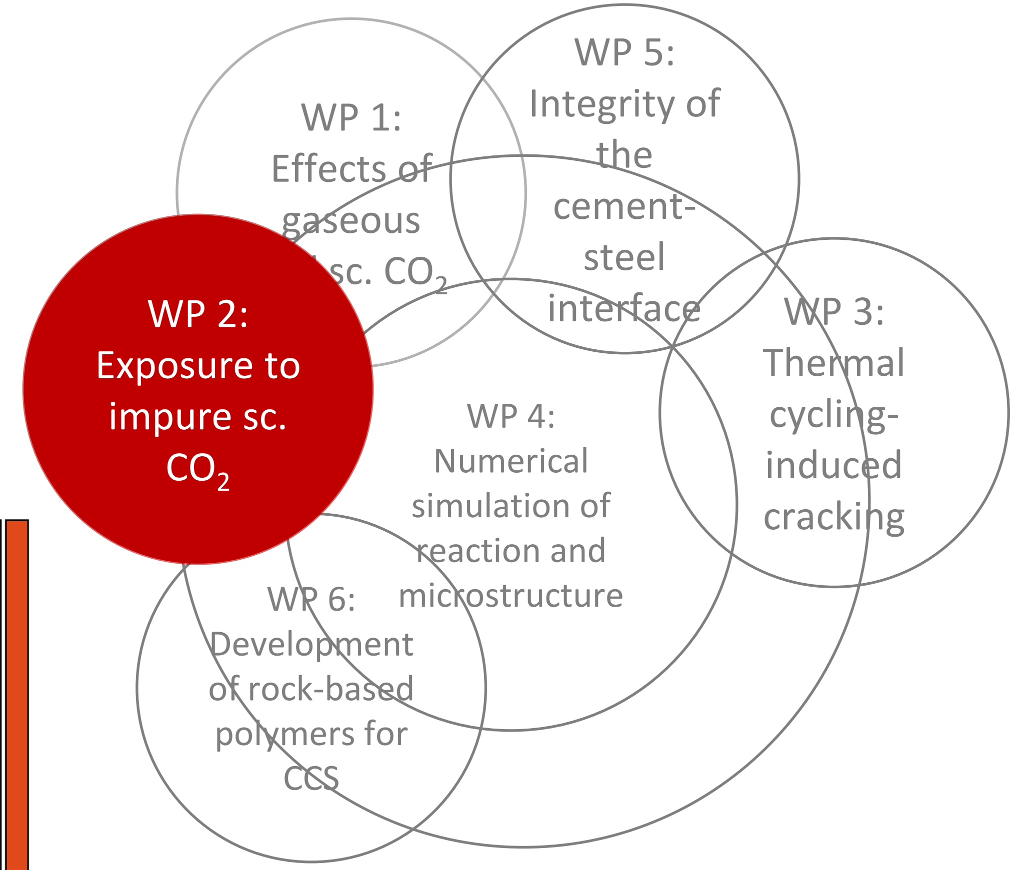
WP2 Exposure to impure supercritical CO_2

- Led by IFE (Corrosion department)
- Exposing selected cement compositions to supercritical CO_2 with H_2S and other impurities
- Observing mineral phase changes (dissolution/precipitation) and changes in microstructure
- Results will be complimentary to those of WP 1



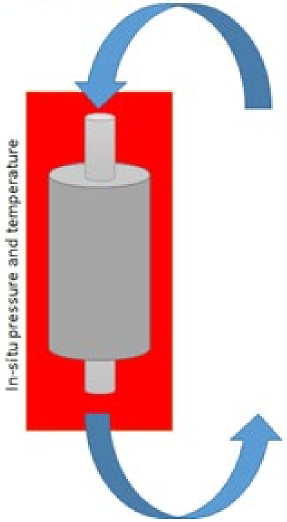


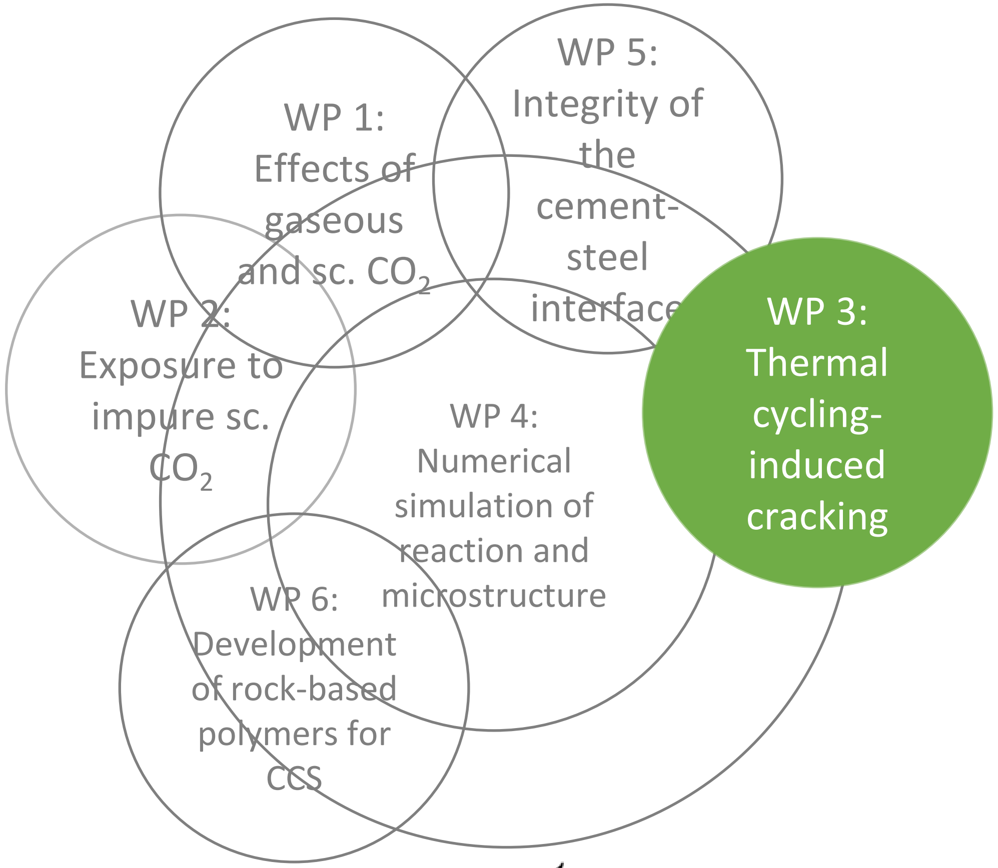
WP3 Thermal cycling-induced cracking

- Led by TU Delft (Geo)
- Exposing hardened cement samples to thermal cycling under in-situ PT conditions
- Exposing samples with a central steel tube to <u>thermal shock</u> through the central tube
- Study annulus and fracture development and the impact thereon of exposure to CO_2 (permeability changes
- Includes one post-doc position

Pressure vessel simulating reservoir pressure and temperature conditions

Flow cold water through simulated wellbore





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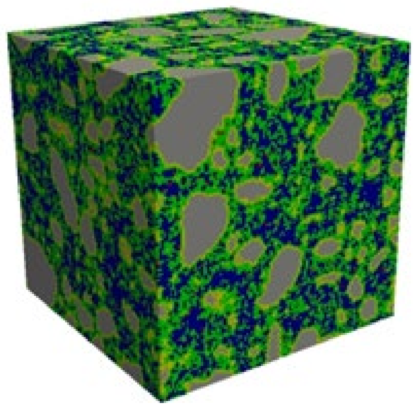
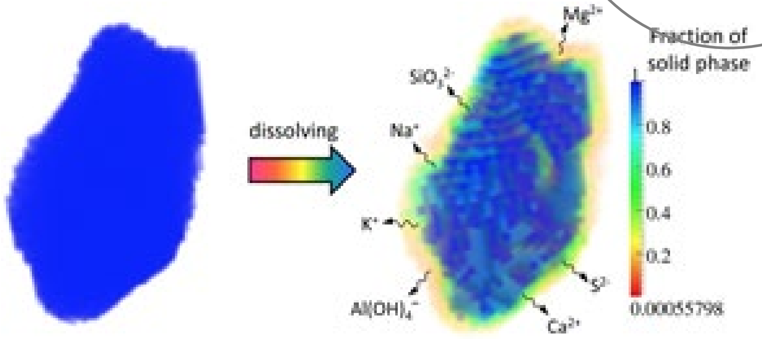
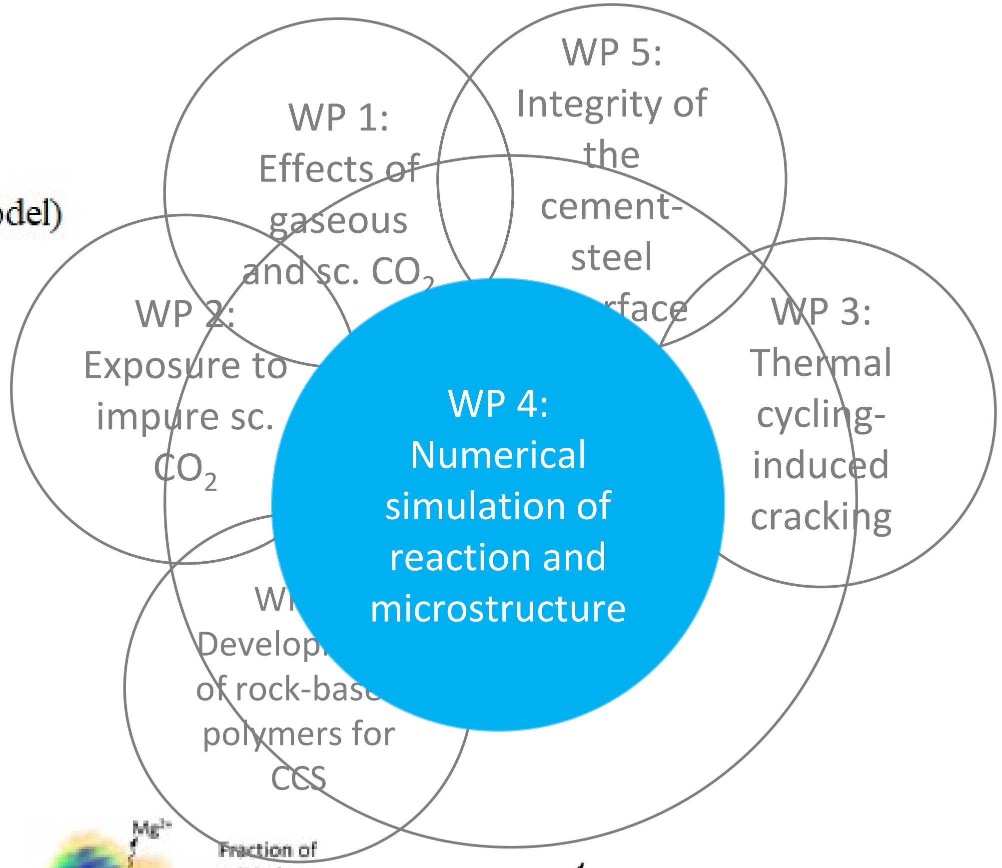
WP4 Numerical simulation of reaction and microstructure

(Simulated by GeoMicro3D model)



- Led by TU Delft (Microlab)
- Numerical simulation of reaction process (hardening) and microstructure development of a rock-based geopolymer compositions (WP 6)
- Numerical simulation of volume stability of geopolymers when exposed to T-variations and CO_2 with impurities
- Includes one post-doc position





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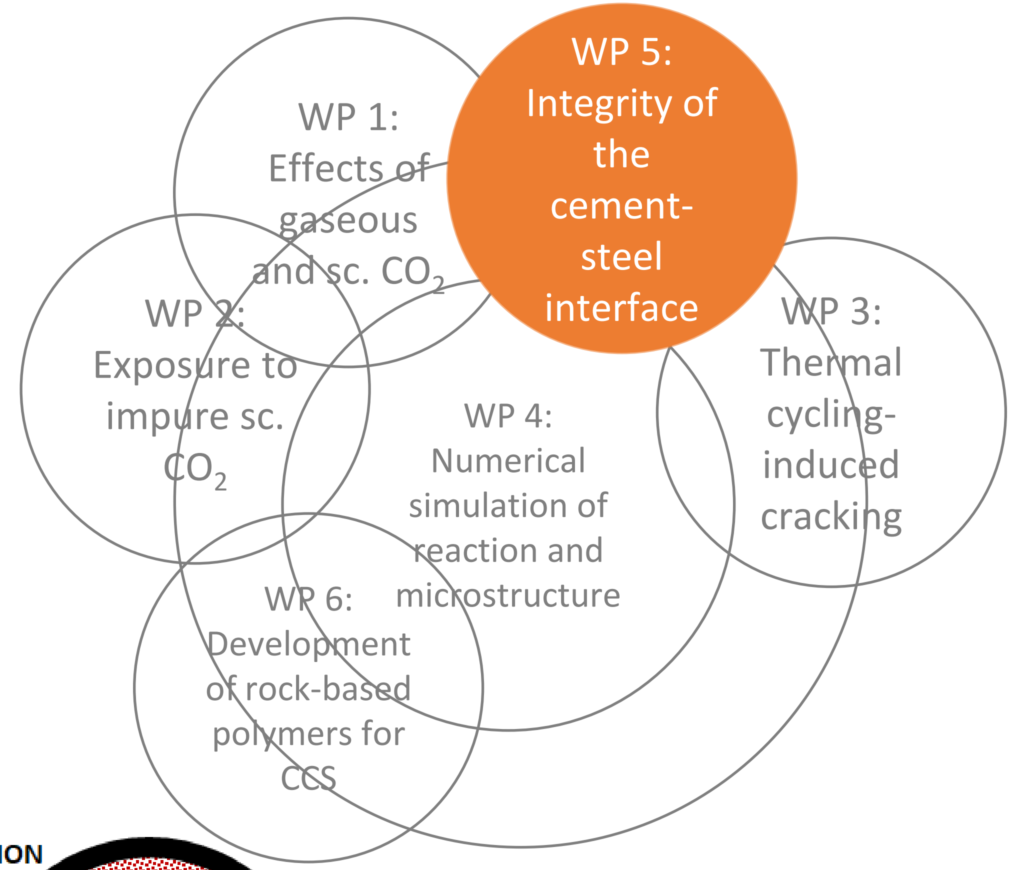
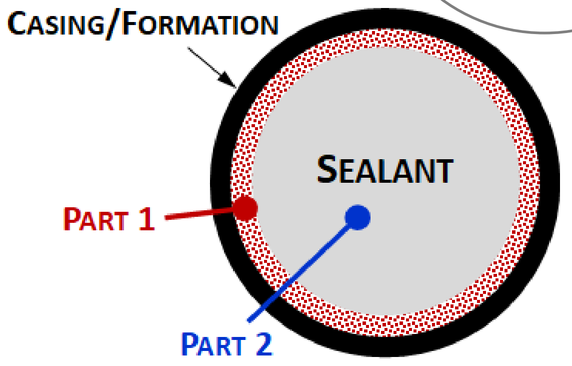
WP5 Integrity of cement-steel interface

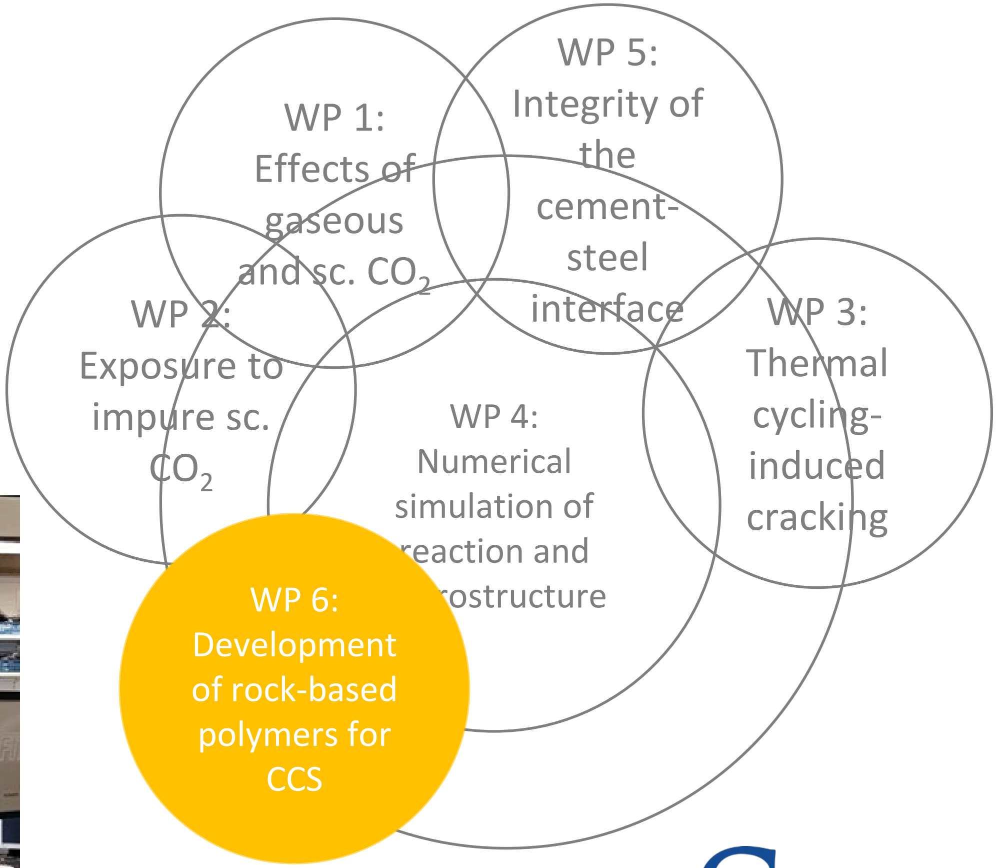
- Led by Heriot-Watt University
- Investigating the interfacial bond strengths of five different sealants with steel casing and host rock
- Effect of CO_2
- Develop electrical impedance-based methods to non-destructively monitor interface integrity (part 1) and explore self-monitoring properties of sealant (part 2)
- One PhD





WP6 Development of rock-based polymers for CCS

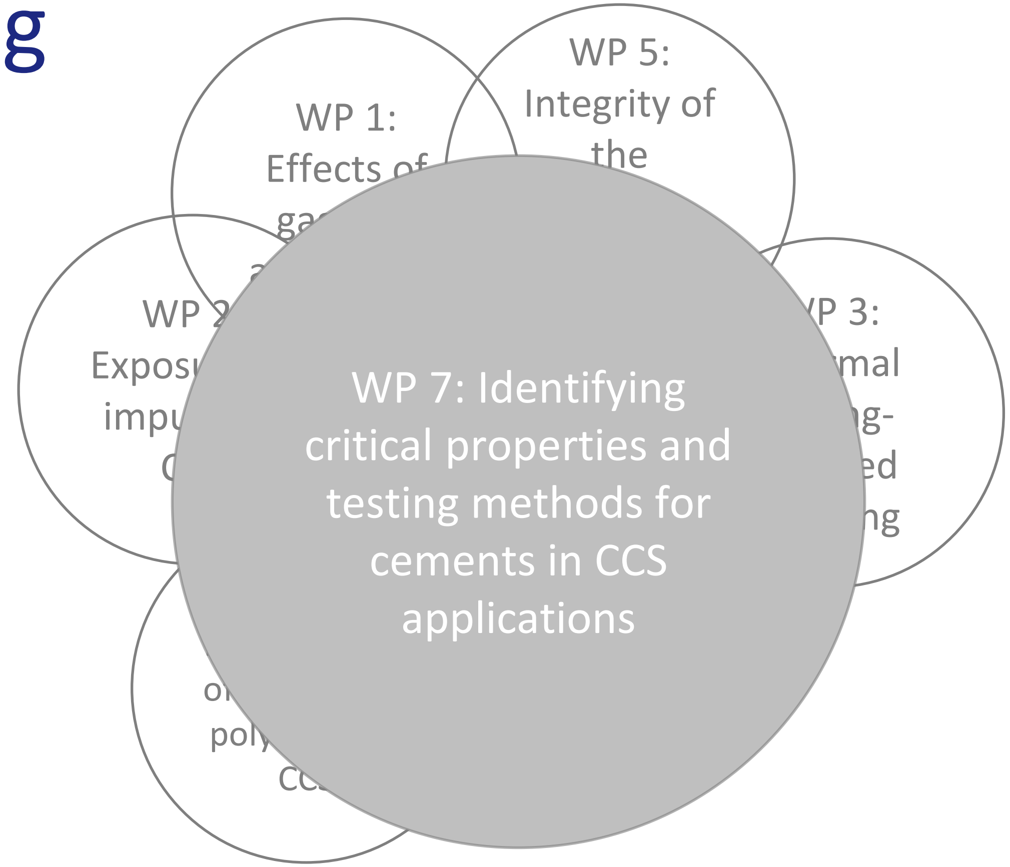
- Lead by the University of Stavanger (UiS)
- Development and characterization of rock-based geopolymers for CCS wells
- Based on existing geopolymers for oil & gas wells
- Focus on both flow/placeability properties, and seal integrity.
- One PhD-student



Universitetet i Stavanger

WP7 Critical properties and testing methods for cement in CCS

- Led by IFE (Reservoir department)
- Based on the results obtained in the preceding six work packages
- Identify key properties that will ensure long-term integrity of sealant materials in CCS applications
- Propose suitable methods and procedures for measuring these properties, and the impact thereon of exposure to CO_2



Expected project outcomes

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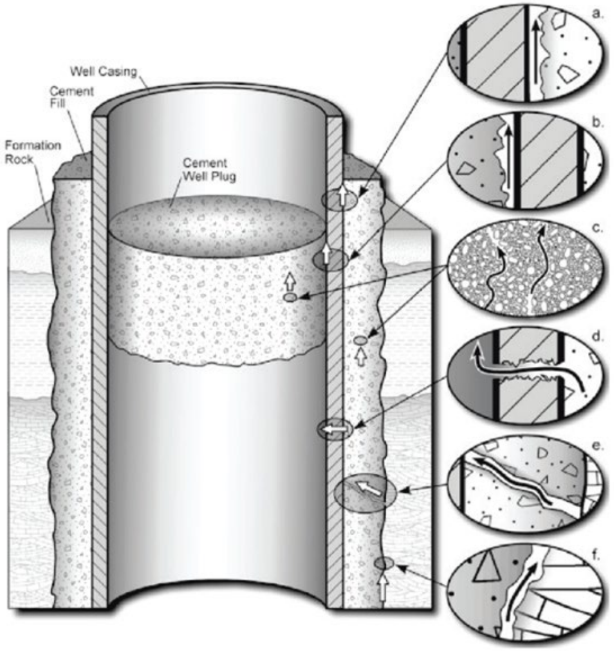
CEMENTEGRITY will:

- Improve the understanding of leakage pathways
- Identify key properties for the prevention of leakage
- Set procedures for the testing of novel sealants for CCS
- Test five sealants of different compositions
- Develop at least one geopolymer composition specifically to withstand conditions encountered during CCS.

Support the development of new sealants:

- That have a smaller environmental footprint (lower or no OPC content)
- Can maintain improved seal integrity during and after CCS applications
- Can be used for new wells, as well as plugging and repair of existing wells.



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Questions?

Contact: Reinier van Noort (reinier@ife.no)

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