CO_2CARE

CO_2 Site Closure Assessment Research

Site characterisation workflow for the geological storage of CO_2 - 3rd SiteChar Stakeholders Workshop

Well Integrity Issues

September 24th 2013

Work package 2 – Well Abandonment

Jean Pierre Deflandre

IFP Energies nouvelles

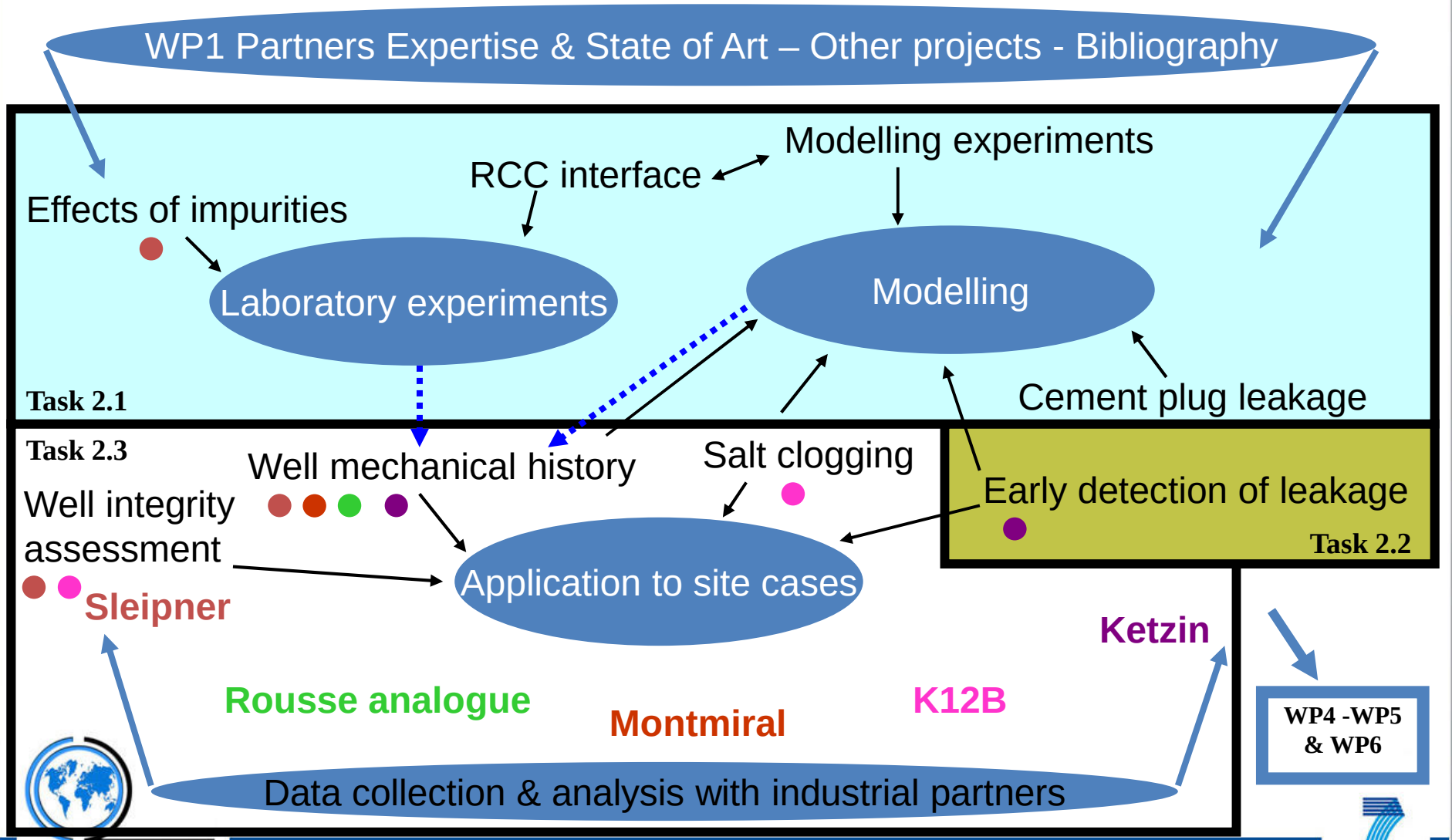
CO_2CARE Objectives relative well abandonment

- How to prepare well abandonment, anticipating any long term risk of CO_2 leakage at wells
- Developments of tools and methodologies to assess the objective: base on laboratory tests, numerical simulations and monitoring feedbacks
- Elaborating recommendations and best practices for risk management and long term site integrity
- Challenging questions prior to abandonment:
  - Do we have identified any deviation from state of art (drilling phase…)?
  - Do we have identified a particular risk from well data?
  - Where are we when considering materials failure/damage envelope?
  - How far from mechanical equilibrium on a fault?

Main technical targets

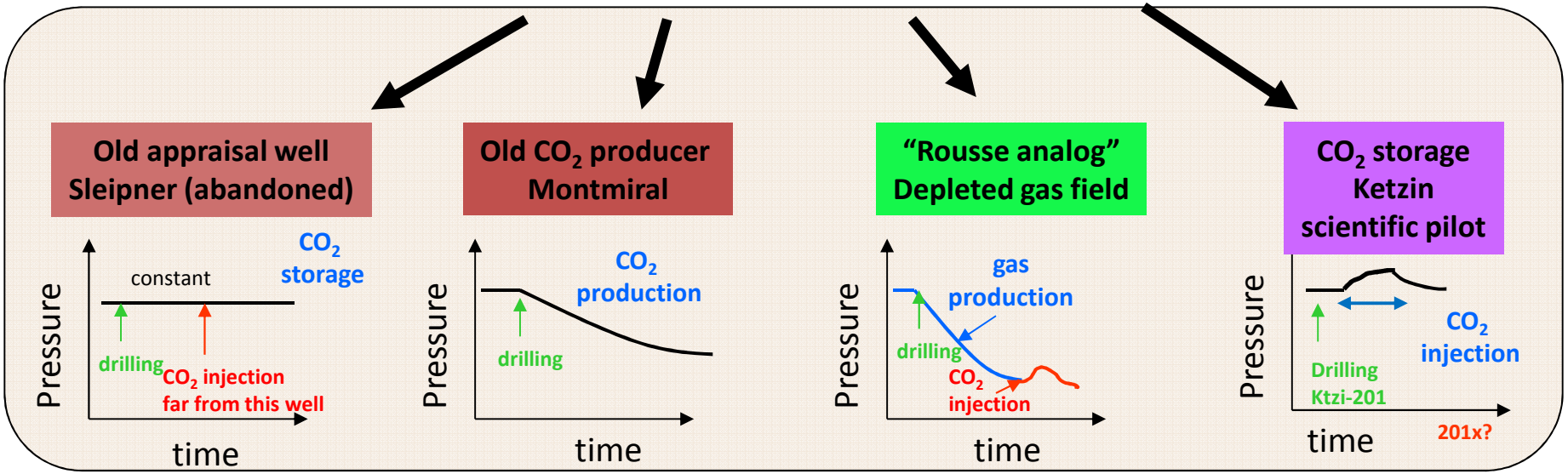
- Being able to state on the **mechanical integrity of a well** (full scale) prior its abandonment
- Investigating of both mechanical and geochemical issues for **casing, cement and caprock interfaces**
- Considering the presence of **impurities in the CO_2 stream**
- Studying innovative closure or remediation techniques based on **salt clogging**
- Testing **wellbore Electro Resistivity Tomography (ERT) monitoring** approach in combination with Seismics for CO_2 migration path imaging

Well Abandonment Work Programme Structure



Well application cases (Task 2.3)

Geomechanical modelling: 4 complementary scenarios



Data collection

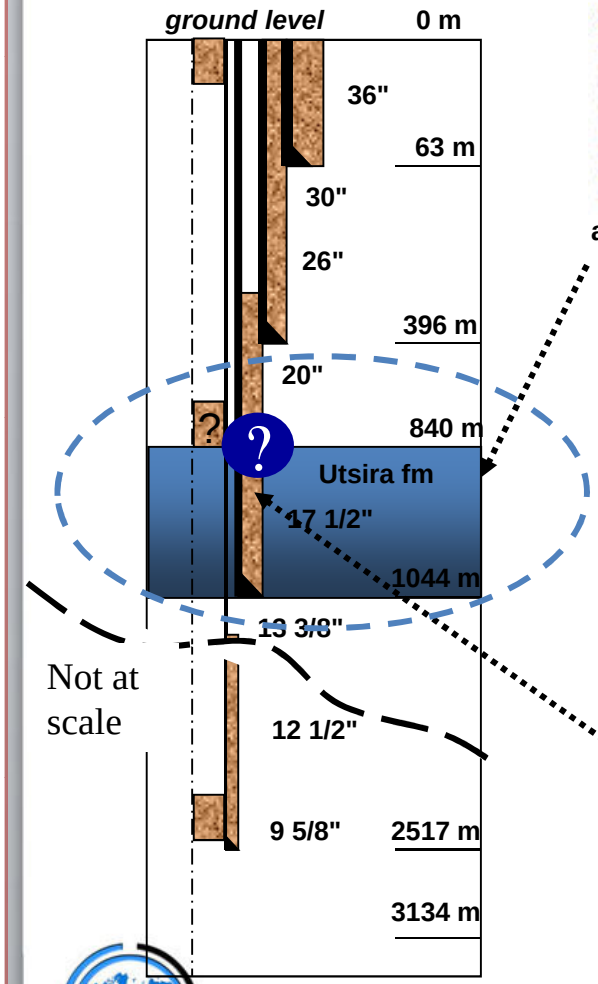
investigations on:

Used to develop the methodology

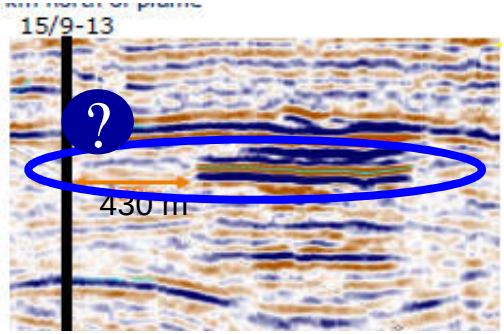
- in situ conditions,
- well geostatic equilibrium and boundary conditions
- meshing / upscaling / refinement
- behaviour laws in media and at interfaces
- integration of 3D field pressure

Well mechanical behaviour: the Sleipner scenario - well 15/9-13

Well 15/9-13
using 15/9-11 info



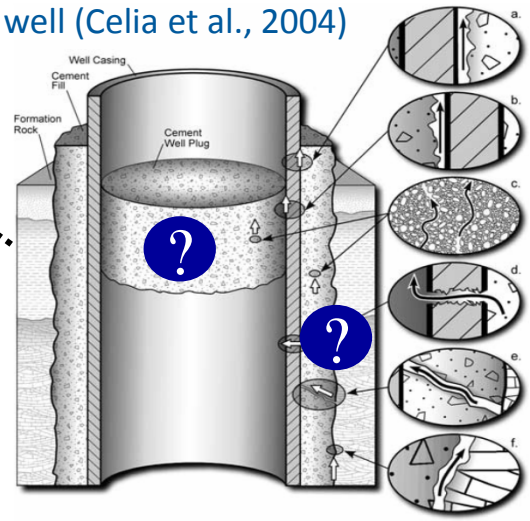
Not at scale

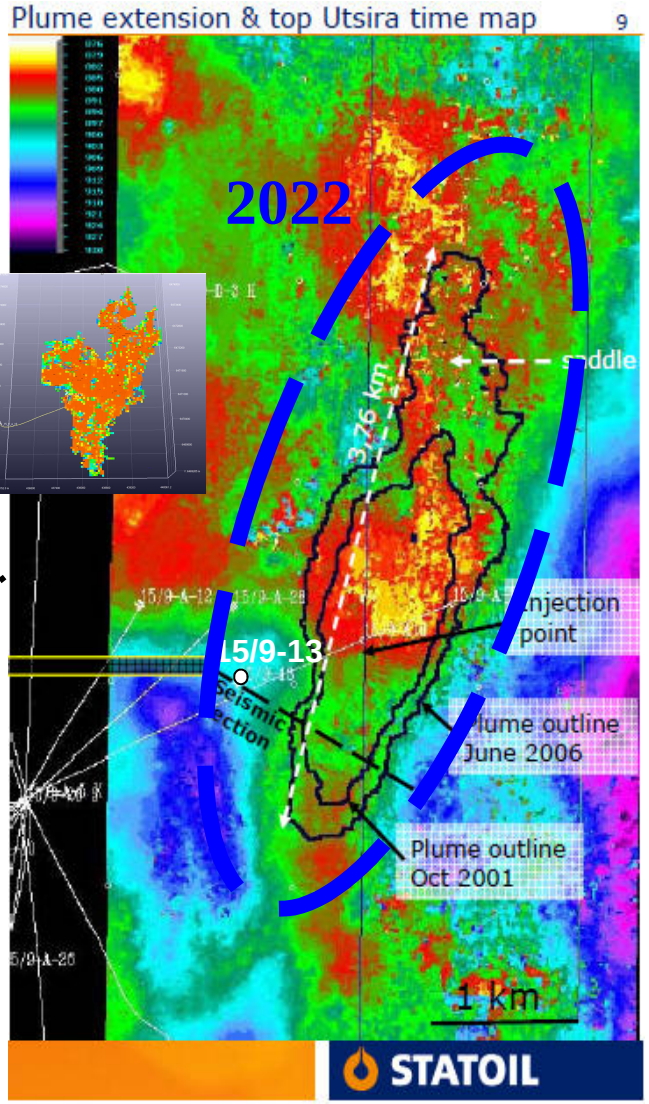


abandoned well reached by the CO_2 plume

In association with WP3 work programme

Possible risk of leakage pathways in abandoned well (Celia et al., 2004)





Inputs from other tasks to consider RCC interfaces and media property evolution

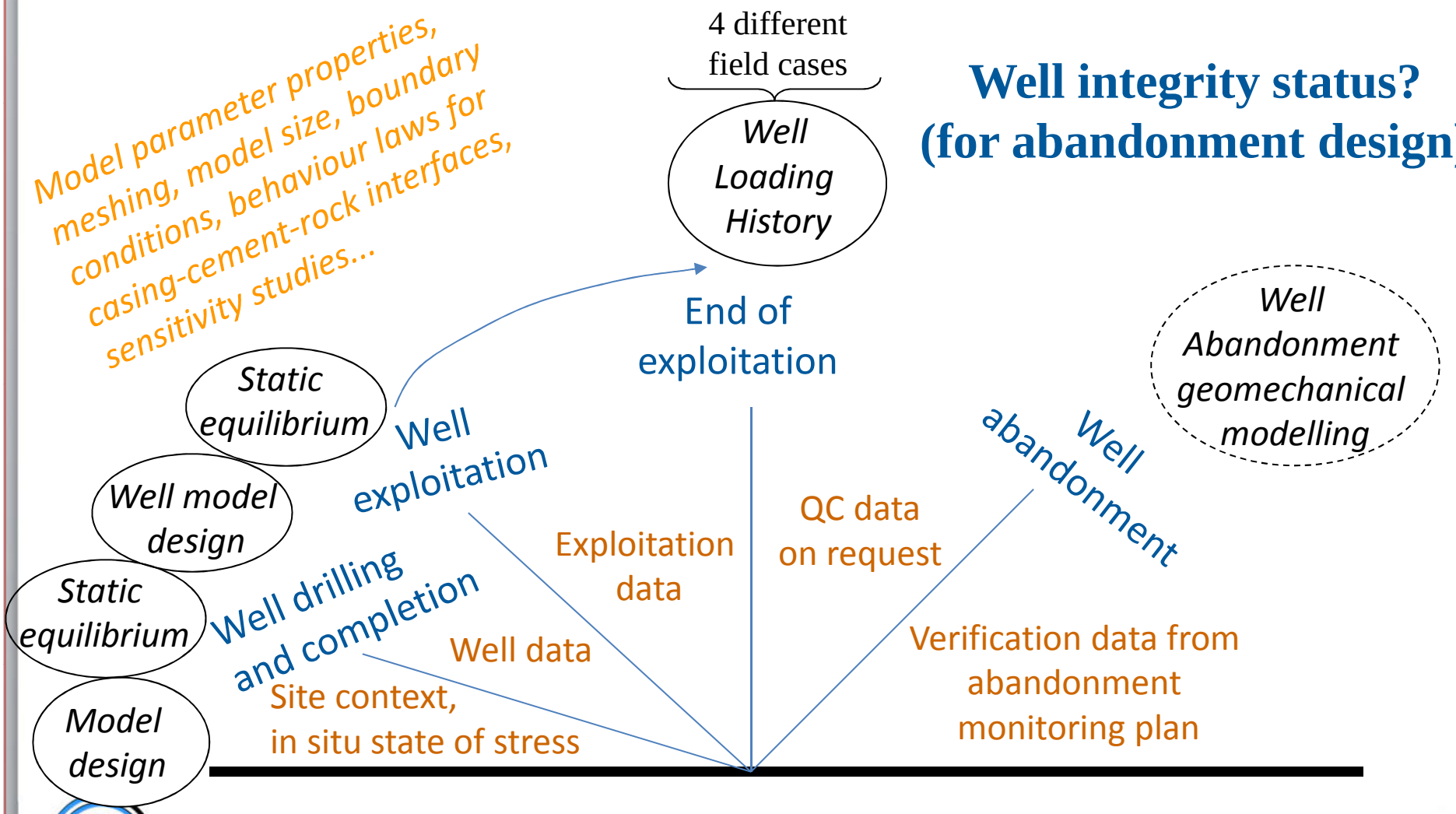
Comments

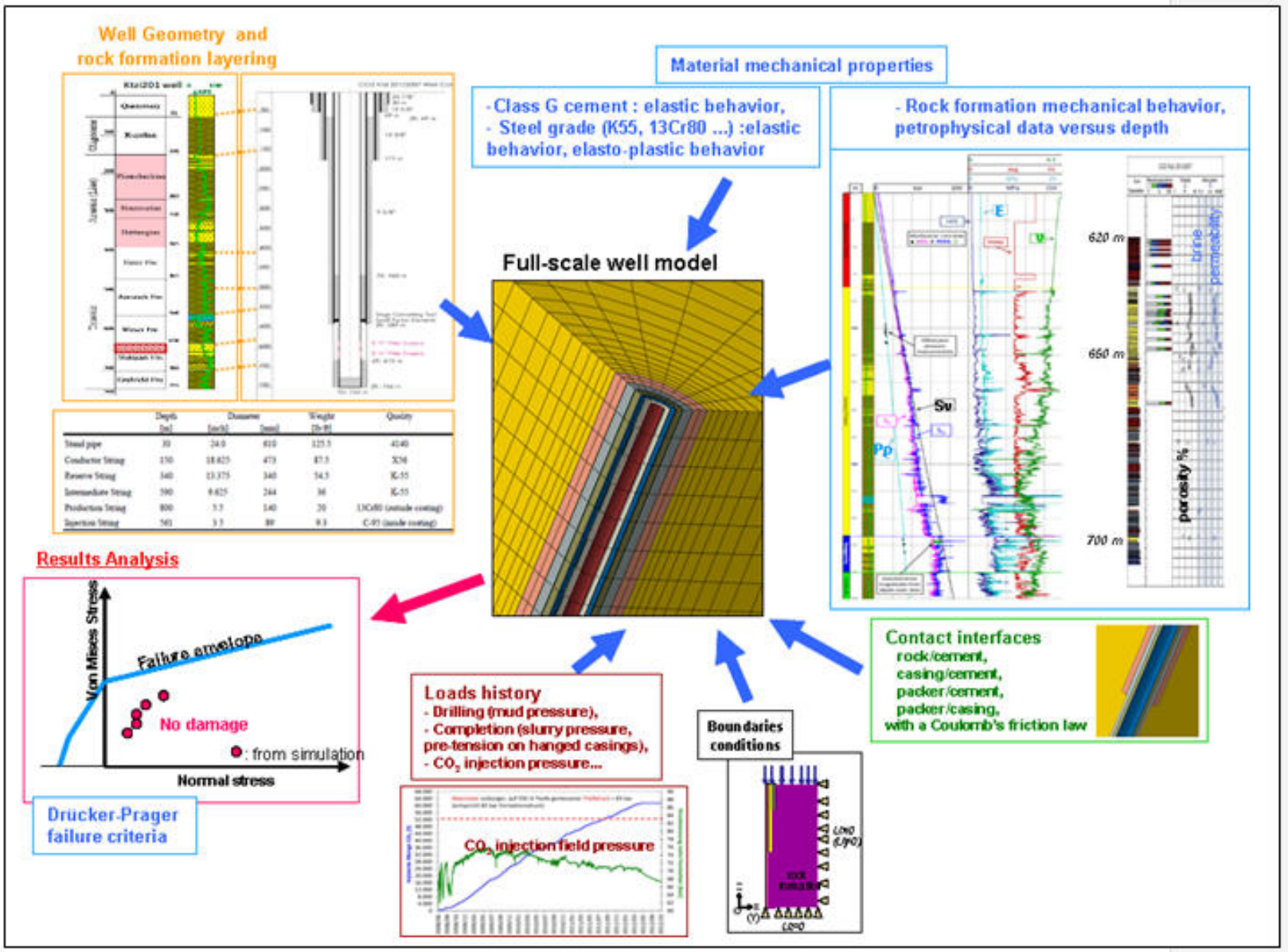
- Reservoir coupled geomechanical modelling at field scale is mandatory to evaluate in situ effective stress variations within the storage complex (assuming no external phenomenon to modify stresses), especially at well location.

- Fine description of CO_2 plume migration and associated CO_2-saturated brine displacement to state on effective risk of leakage

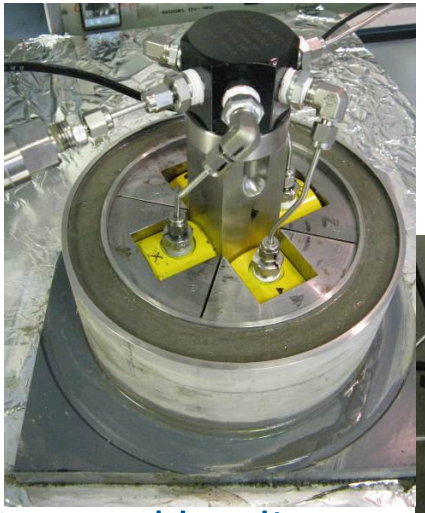
- Similar approach when considering the risk of fault reactivation and CO_2 leakage through a fault

Well mechanical history modelling approach

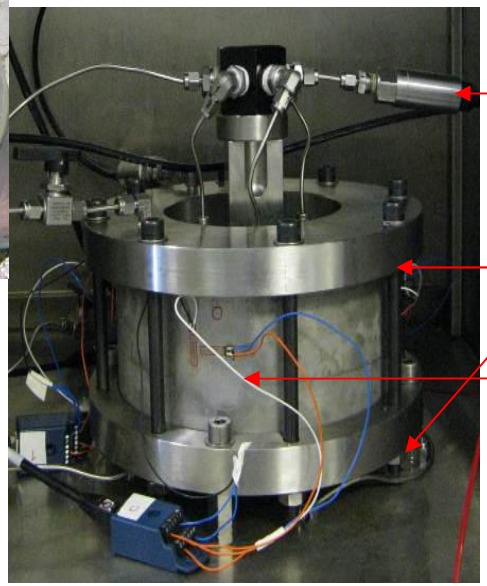



Well Geometry and rock formation layering
Material mechanical properties
- Class G cement : elastic behavior,
- Steel grade (K55, 13Cr80 ...) :elastic behavior, elasto-plastic behavior
- Rock formation mechanical behavior, petrophysical data versus depth
Full-scale well model
Su
Pp
620 m
650 m
700 m
porosity %
Results Analysis
Von Mises Stress
Failure envelope
No damage
: from simulation
Normal stress
Drücker-Prager failure criteria
Loads history
- Drilling (mud pressure),
- Completion (slurry pressure, pre-tension on hanged casings),
- CO2 injection pressure...
CO2 injection field pressure
Boundaries conditions
Contact interfaces
rock/cement,
casing/cement,
packer/cement,
packer/casing,
with a Coulomb's friction law

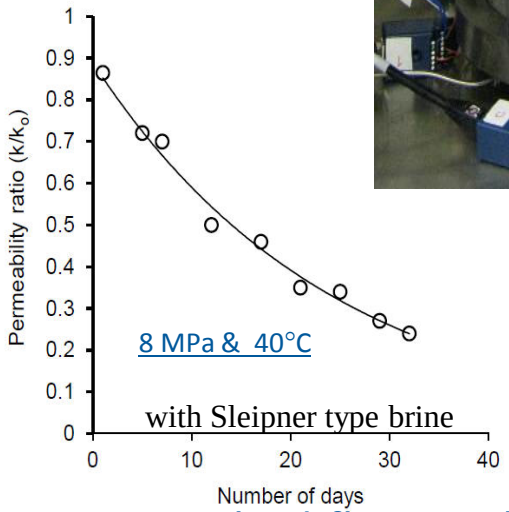
RCC experimental set-up design and calibration



Internal loading system



Investigation of the effects of impurities on Sleipner top-seal specimen

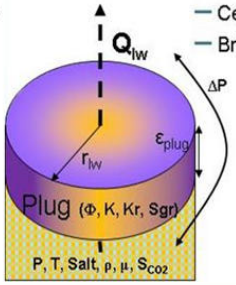


Fluid flow in the microannulus as in fracture

Analytical modelling of cement plug leakage

> **Analytical multiparameter model**
- Determination of leakage rate Q_{lw}
- Determination of key timescales

> **Sensitivity analysis on different parameters:**
- Overpressure ΔP
- Plug geometry (r, ε)
- Cement properties (Φ, K, Kr, Sgr)
- Brine properties (P, T, Salt => ρ, μ, CO_2-Solubility)



Conclusions / comments

- Data collection / Data availability / Data relevancy
  - → "Quick look risk analysis"
  - → Tracking any deviation to state of art
- Physical & numerical modelling issues
  - Measurements time scale at laboratory (especially when dealing with corrosion and geochemistry)
  - Huge diversity of possible interacting materials / molecules
  - Material constitutive laws and parameters values → **Laboratory tests**
  - Boundary conditions / initial values (such as σ_i) → **Site characterization**
  - Computation issues
- Monitoring issues
  - Lack of baseline data
  - Technological improvements over decades
  - Remediation or abandonment "validation/verification"