



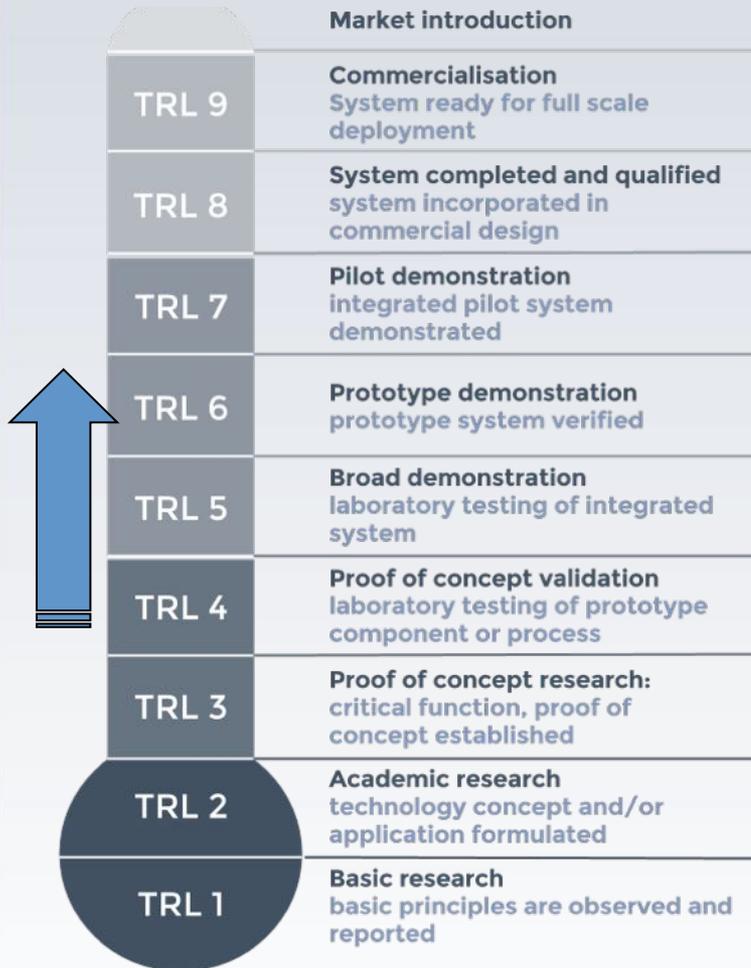
Preparation for a pilot project of a CO₂ geological storage in Czech Republic

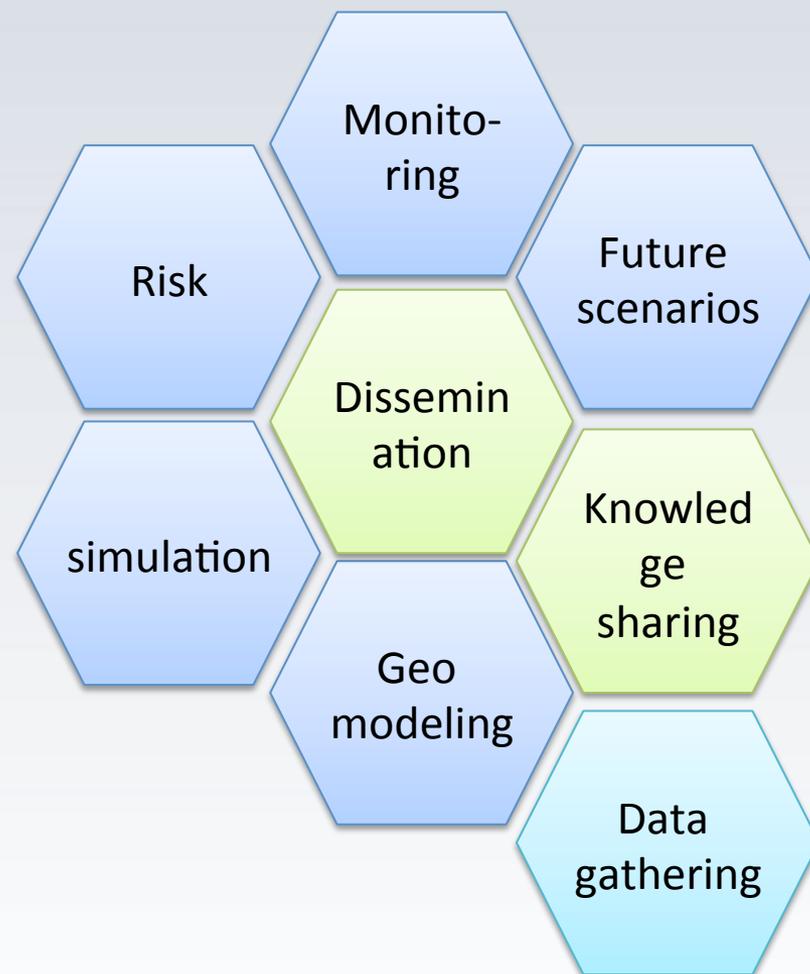
Activity 3 team, presented by Roman Berenblyum

April 2016

The vision

Slowing down the global warming by preparing for a pilot of a large scale CO₂ storage in Vienna basin



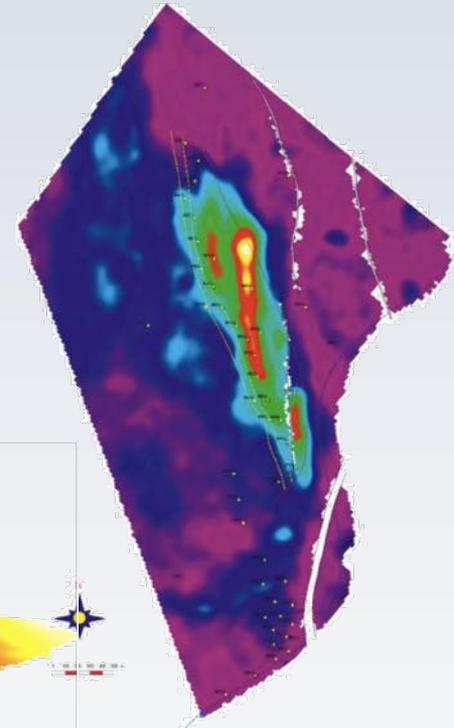
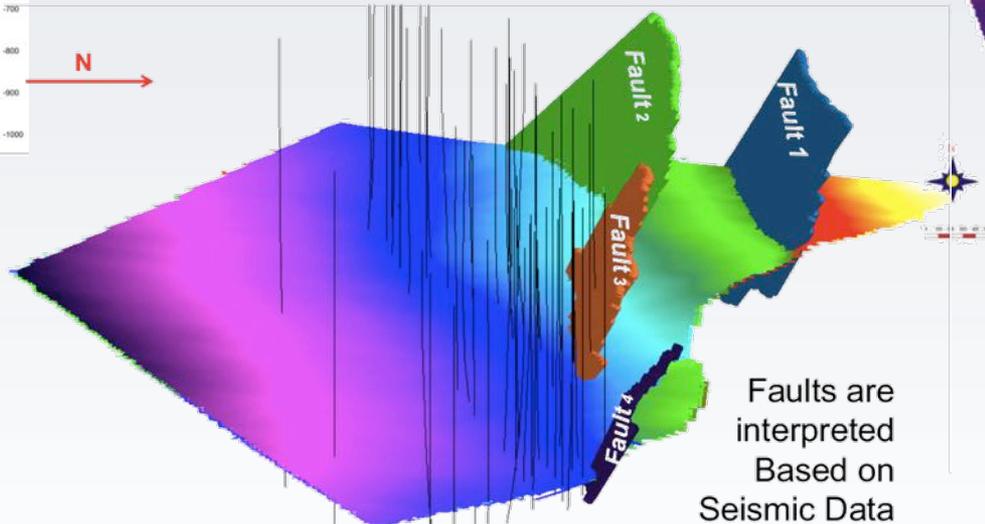
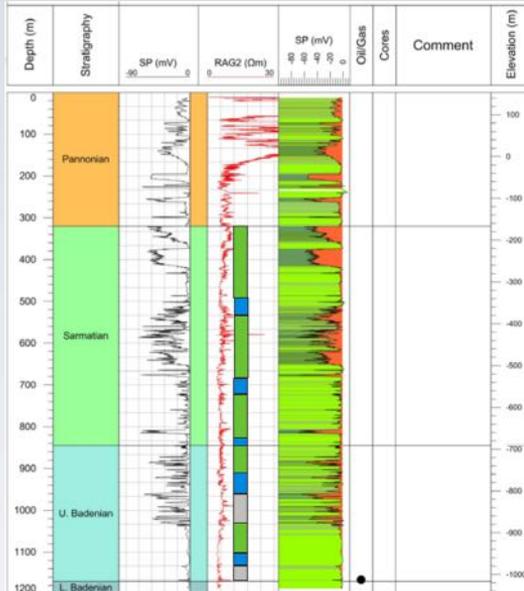


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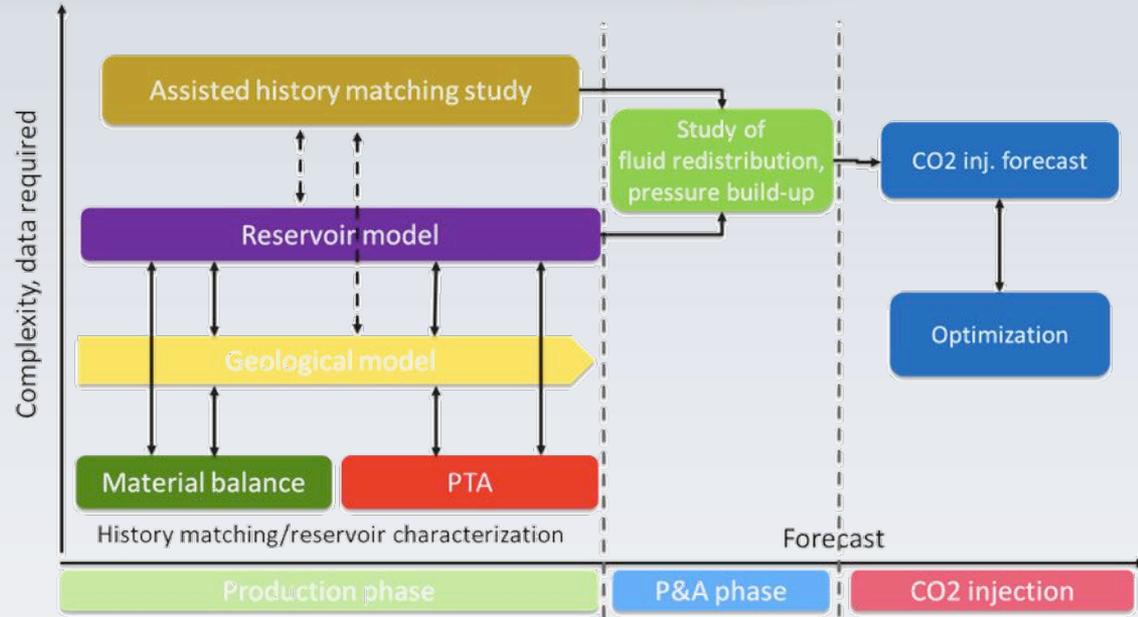
- Field under production in 60's and 70's
 - Scarce and often uncertain data...
 - Yet its still more than what we know about “common” aquifer
 - Small field, yet representative of Vienna basin
 - Recent re-abandonement
 - Recent re-view of restarting gas production
 - Old abandoned fields are likely storage candidates

Starting point: G&G

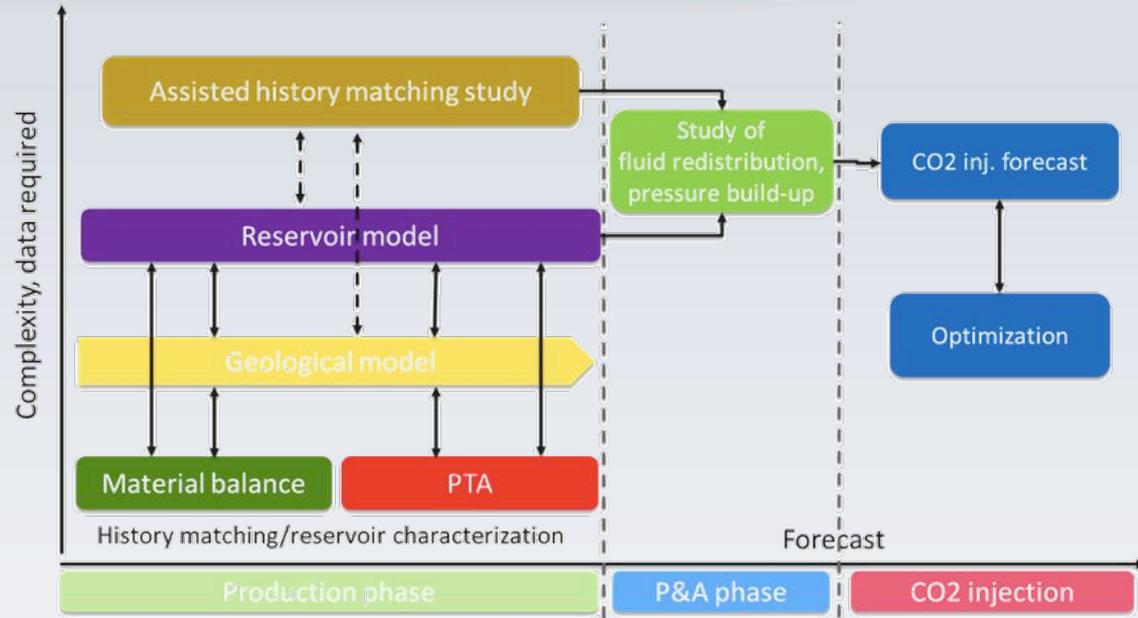
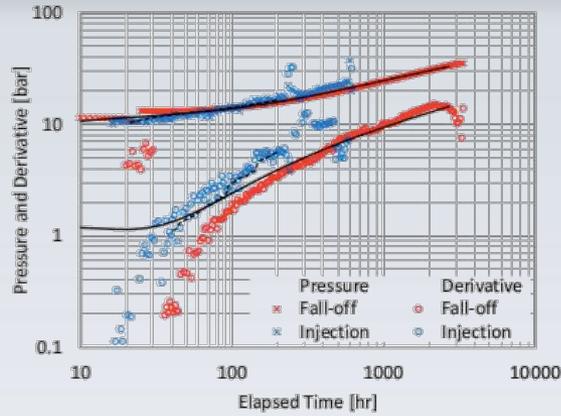
Re-interpretation of existing data – new 3D seismics – new geological model



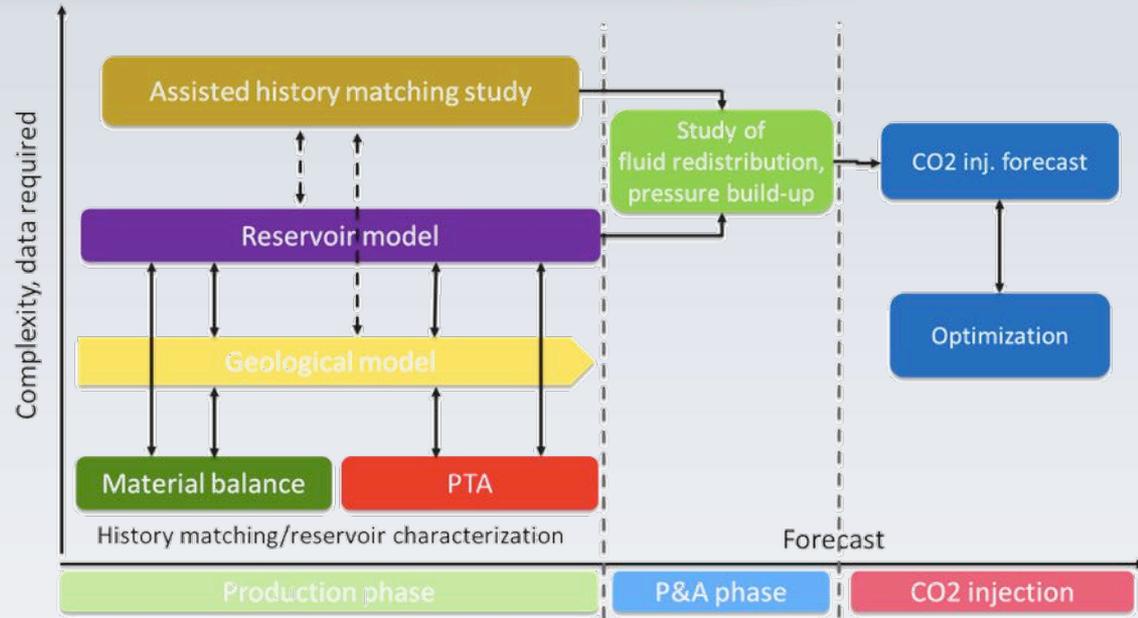
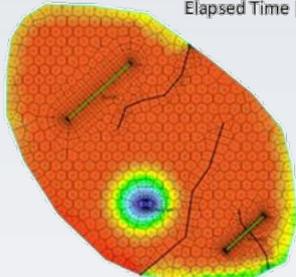
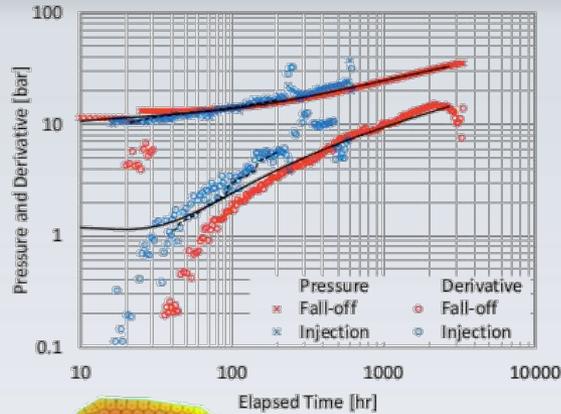
Concepts: simulation



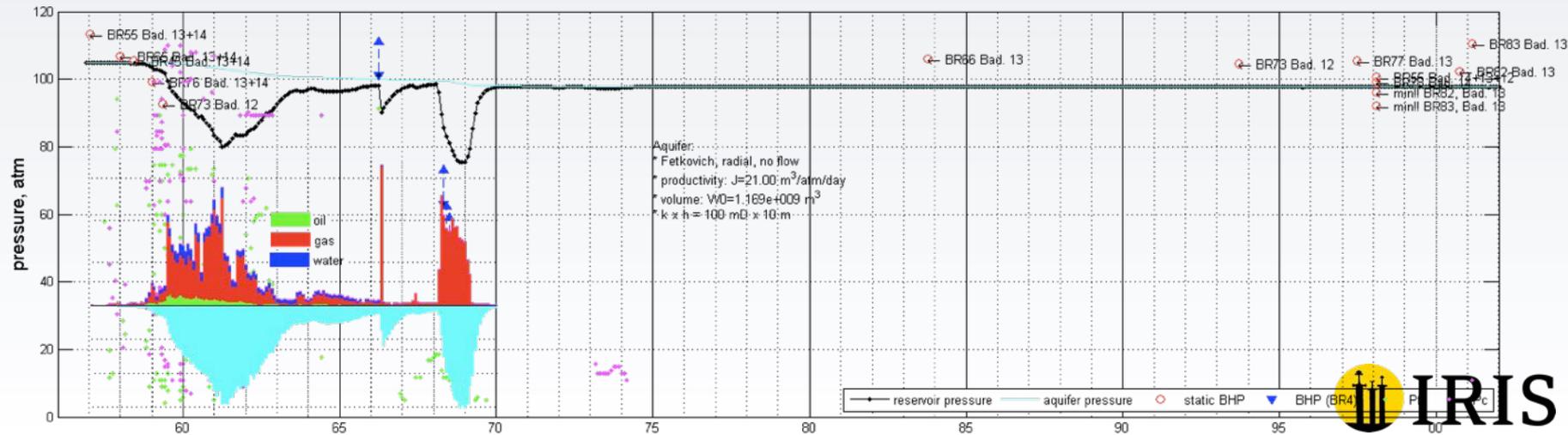
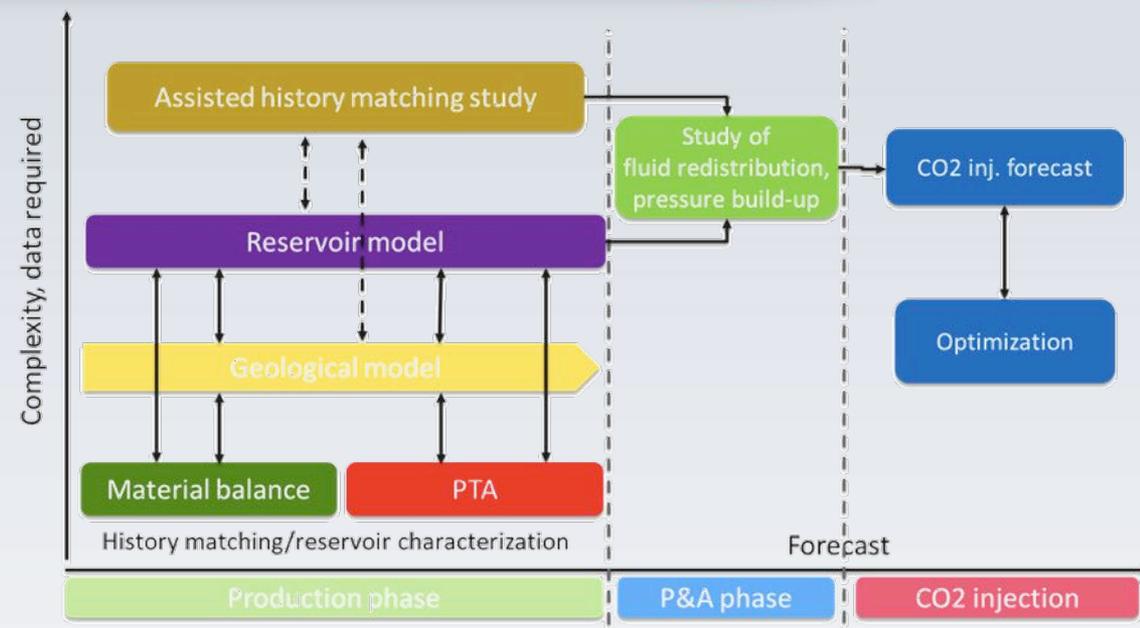
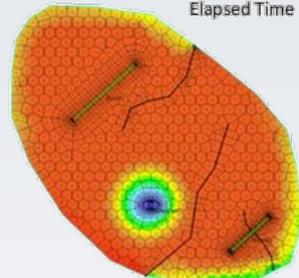
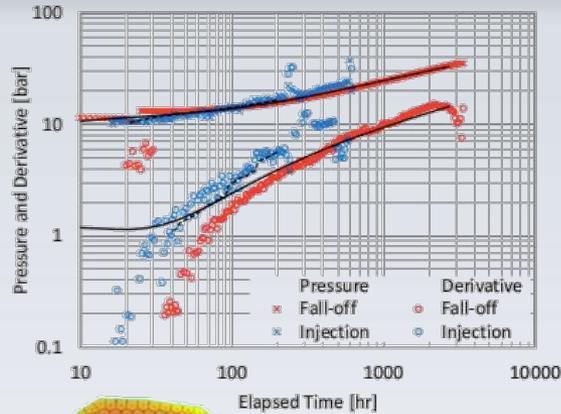
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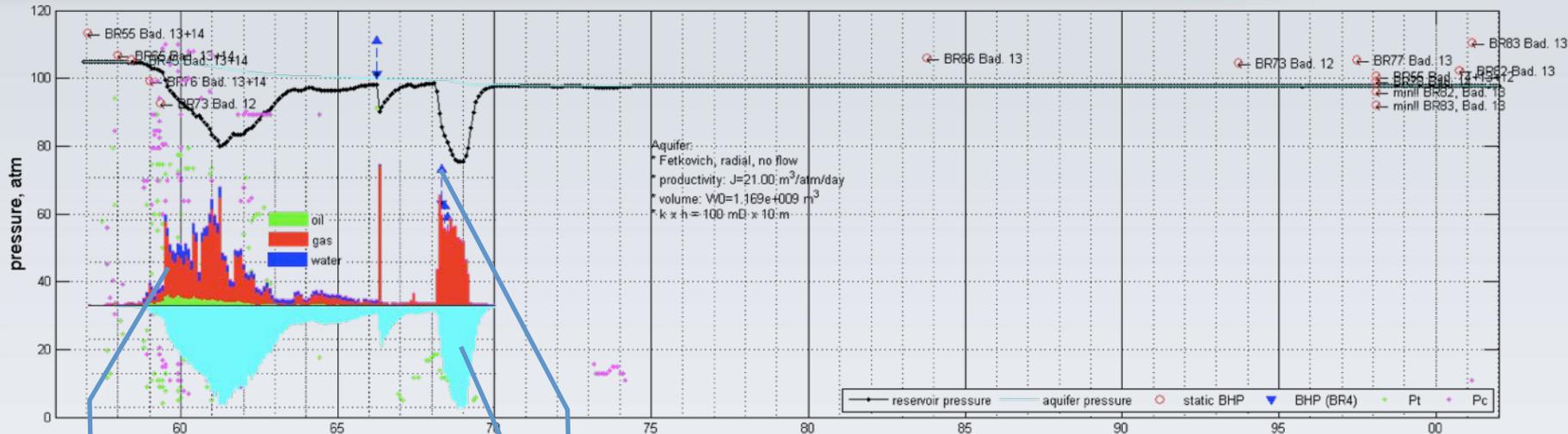
Concepts: simulation



Concepts: simulation



Pre-study



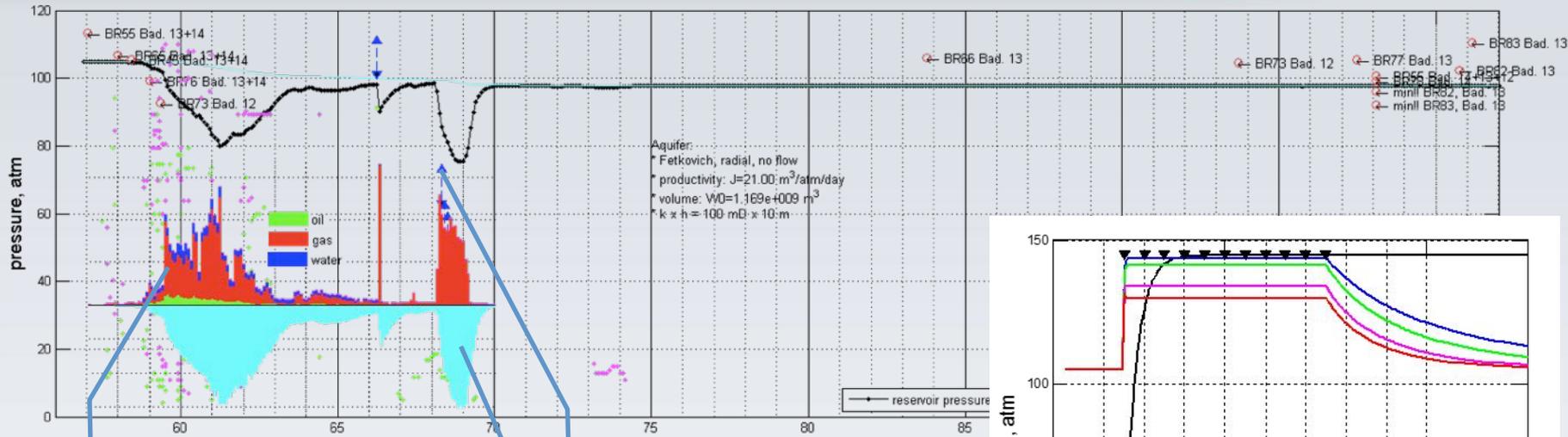
Actual production data

Utilizing all available pressure data

Matching aquifer behavior using the same model as in full field runs

- Screening uncertainty in reservoir properties
- Injection prediction capability
- Fast screening of various risk scenarios

Pre-study

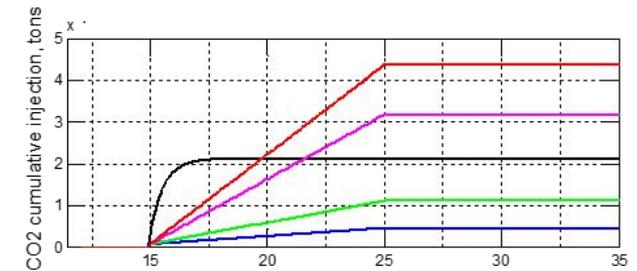
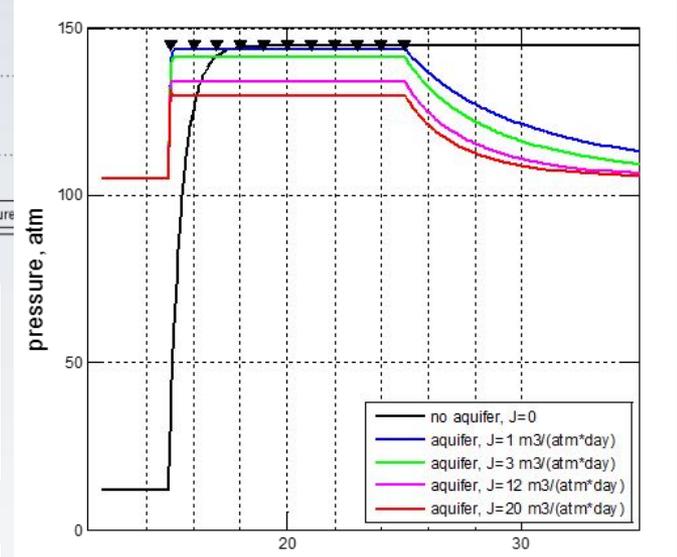


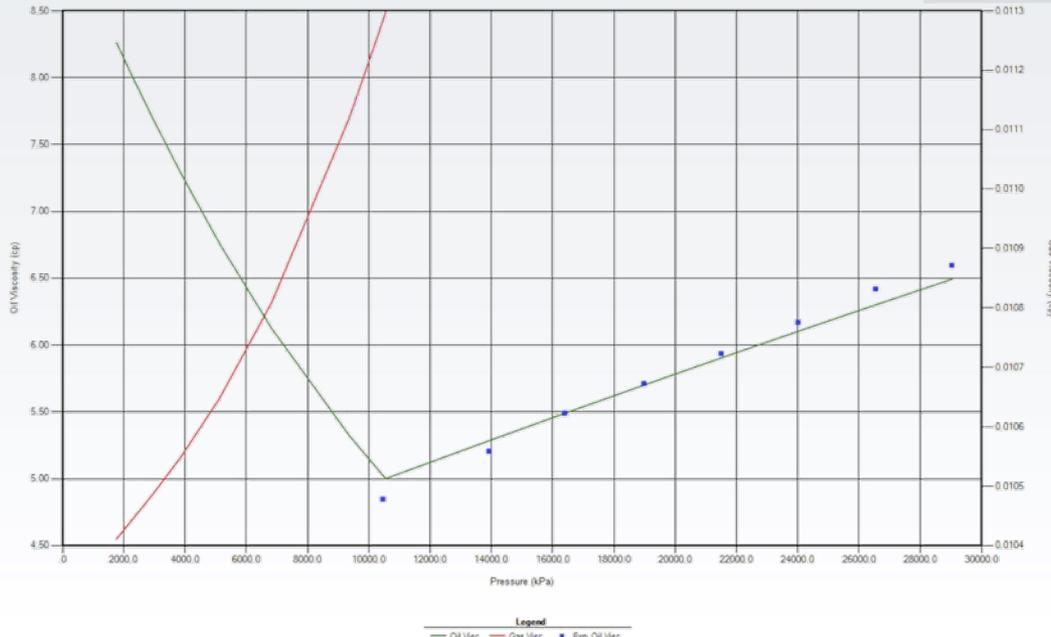
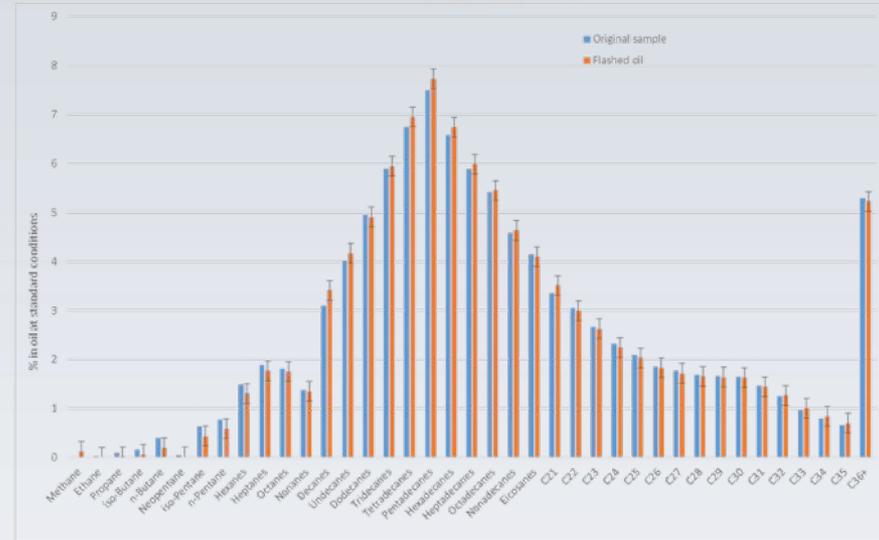
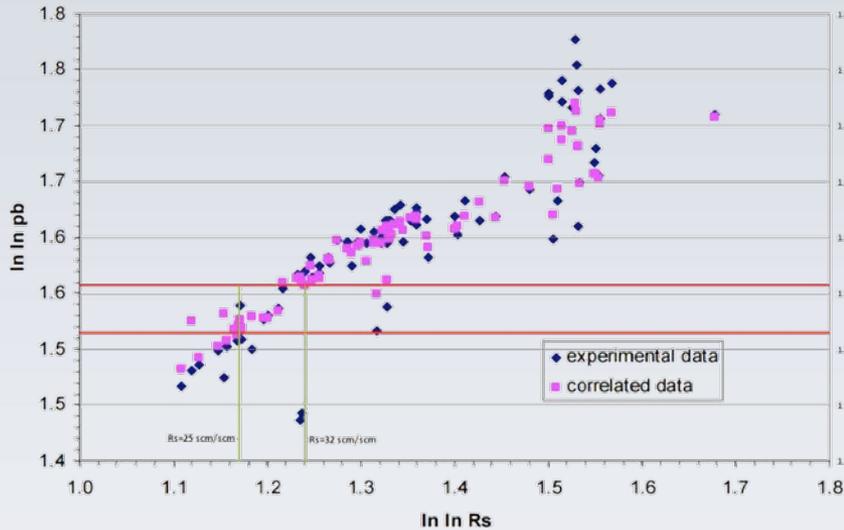
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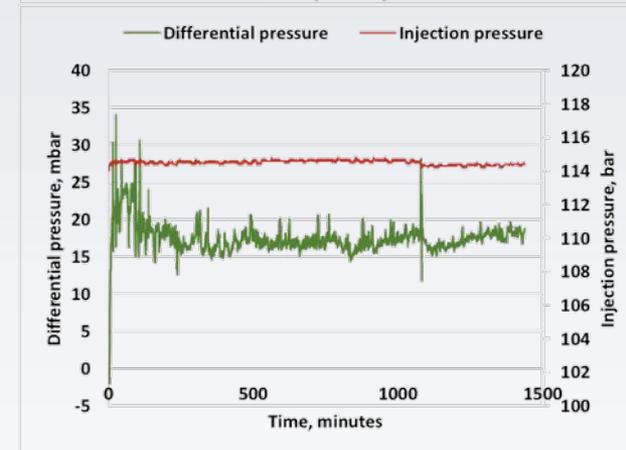
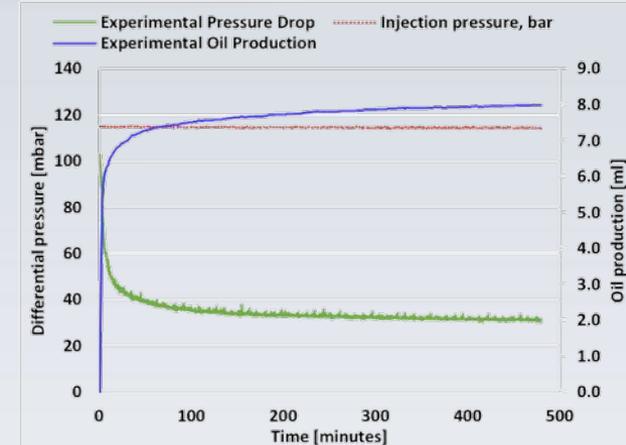
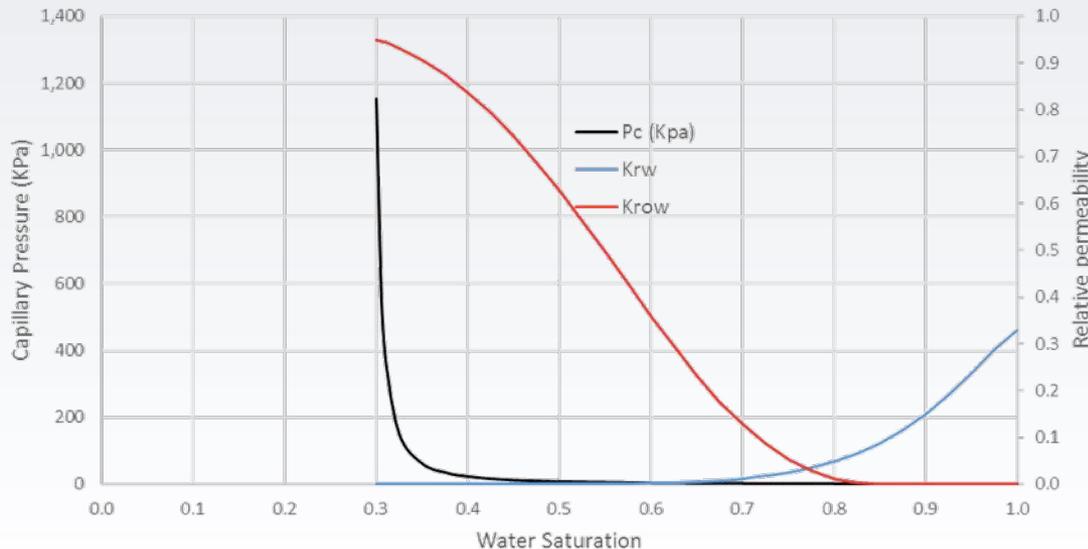
Two model realisations:

- Two component “black oil like” to speed up history matching process
- 8-component compositional for CO₂ injection

Vital steps:

- Establish S_{wi}
- Wettability restoration at reservoir conditions

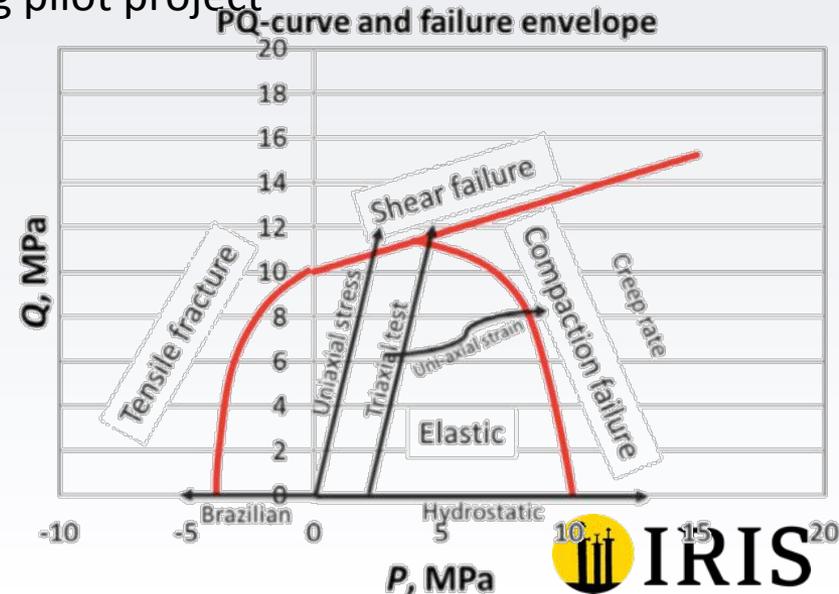
After flooding relative permeability and capillary pressure are back-calculated using in-house algorithms.



Geomechanics

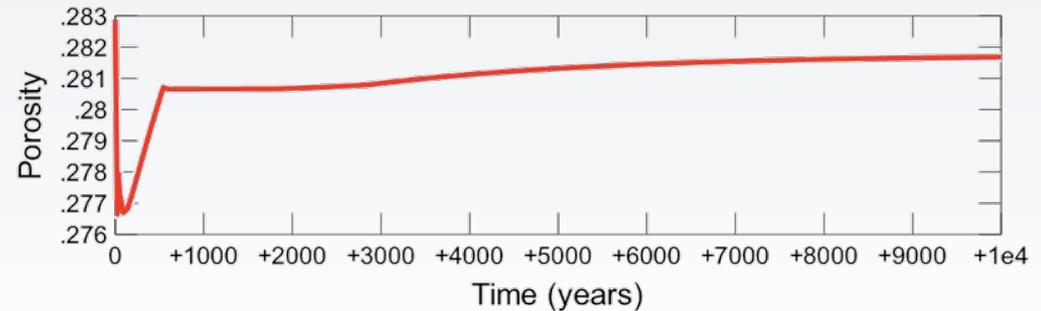
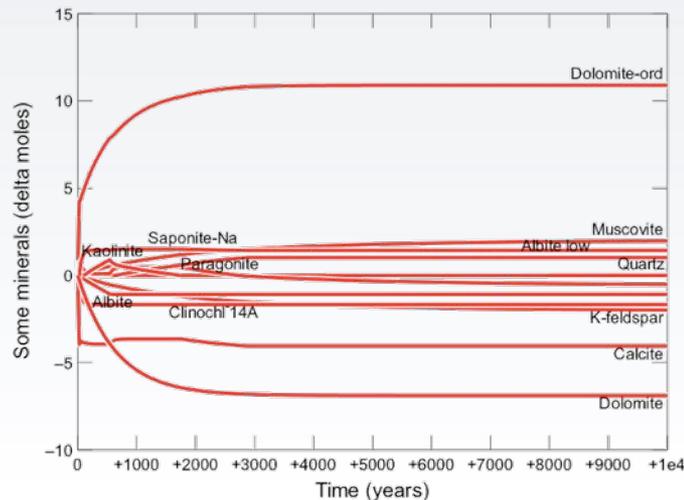
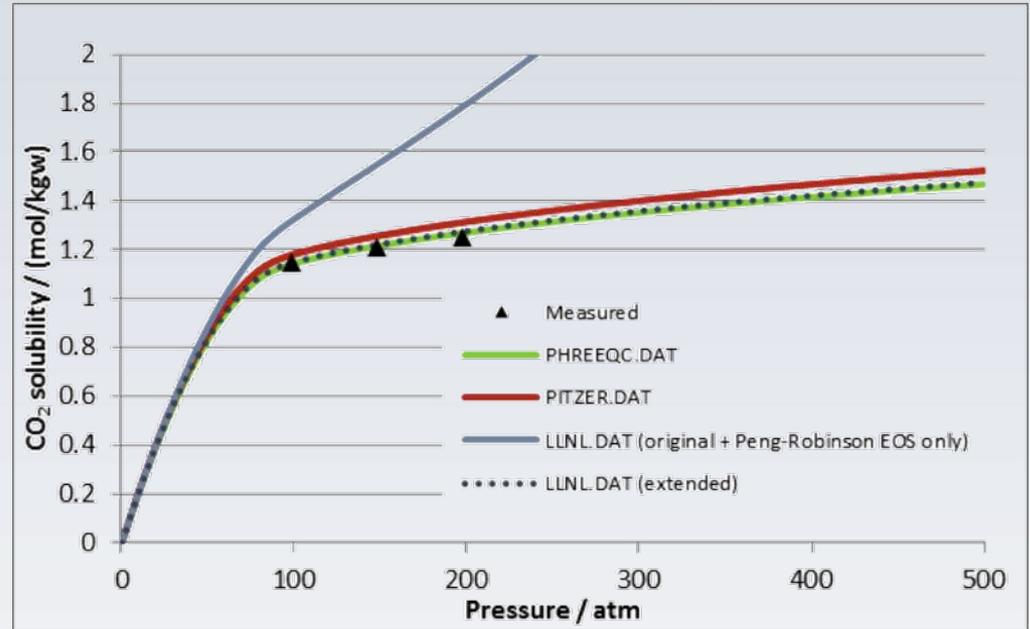
- Links between geomechanical experimental studies, simulation and risk studies
 - Rock core sample after flooding
 - Implementation of current data to reservoir simulation
 - Reducing operational envelope
 - Designing future activities required during pilot project
 - Fault stability evaluation

- In-field stresses and direction



Geochemistry

Mineral	Brodske-45 Aquifer - Badenian (1171,5-1173,5 m)
Quartz	40,35
Albite	8,36
K-feldspar	2,99
Clinochlor 14 A	4,74
Muscowite	17,3
Kaolinite	6,71
Calcite	12,31
Dolomite	6,06
Pyrite	0,66
Gypsum	0,52



Geochemistry

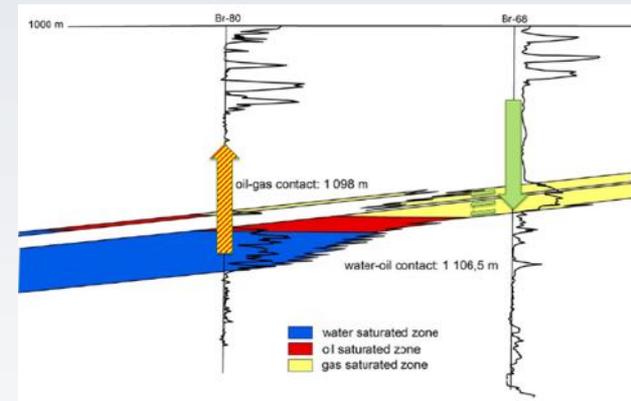
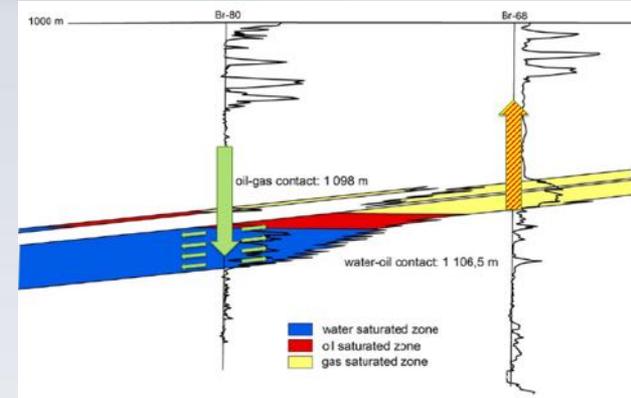
1. CO₂ dissolution in brine
2. Interaction of CO₂ with reservoir rock
3. Interaction of CO₂ with reservoir seal
4. Fault reactivation?
5. Interaction CO₂ with cement in old wells (aimed at assessing the integrity of the cement).

Storage

Pressure relief

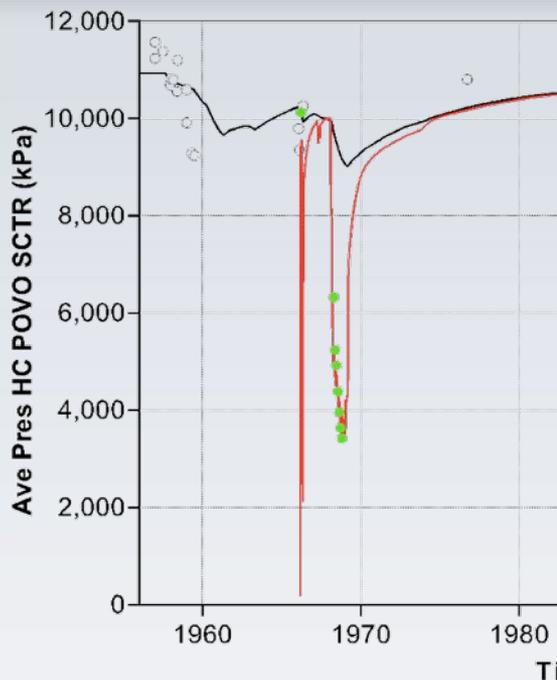
EOR

Scenario	Weights
Pure storage	$w_{CO_2} > 0; w_{oil} = 0; w_{gas} = 0; w_{water} = 0$
Storage in aquifer with pressure relief	$w_{CO_2} > 0; w_{oil} = 0; w_{gas} = 0; w_{water} > 0$
Storage in abandoned field without EOR but with pressure relief	$w_{CO_2} > 0; w_{oil} < 0; w_{gas} < 0; w_{water} > 0$
Storage and EOR	$w_{CO_2} > 0; w_{oil} > 0; w_{gas} > 0; w_{water} > 0$

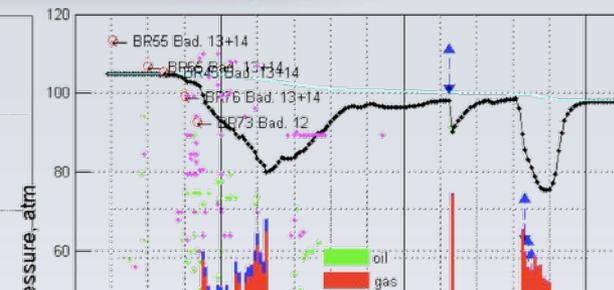


$$F = \sum_{t=0}^T \frac{w_{CO_2}(t)Q_{CO_2}(t) + w_{oil}(t)Q_{oil}(t) + w_{gas}(t)Q_{gas}(t) - w_{water}(t)Q_{water}(t)}{N_w(t)} \rightarrow \max$$

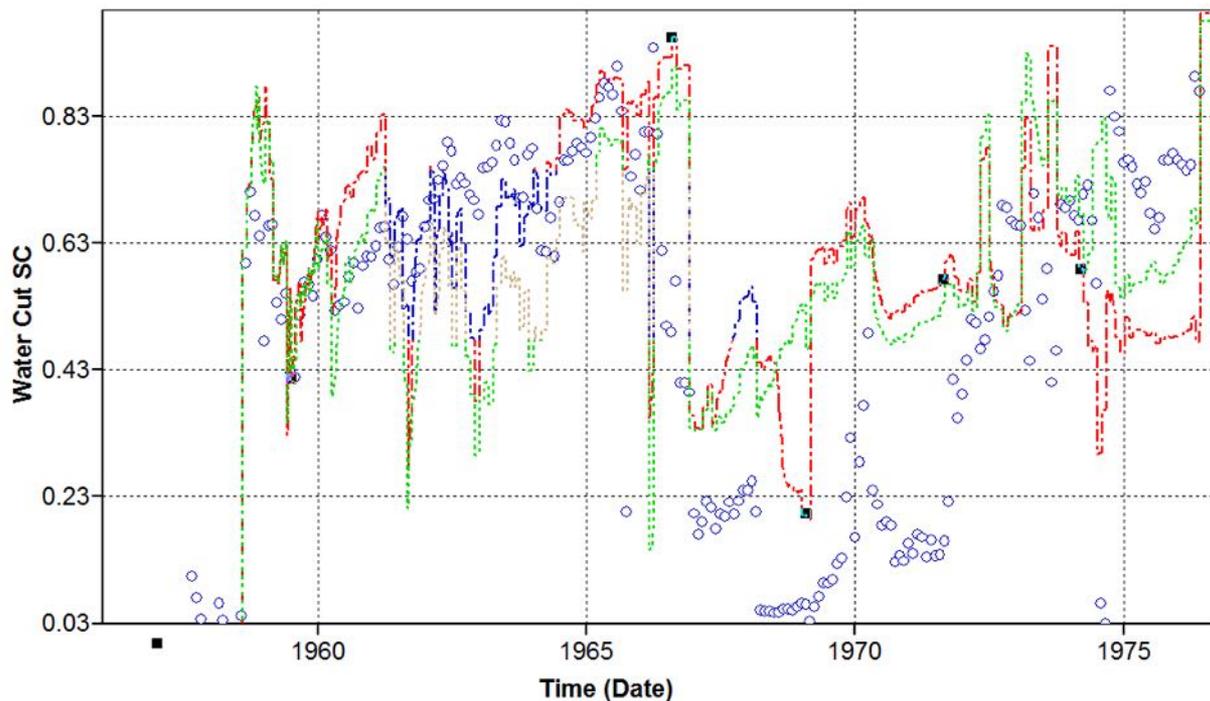
History match



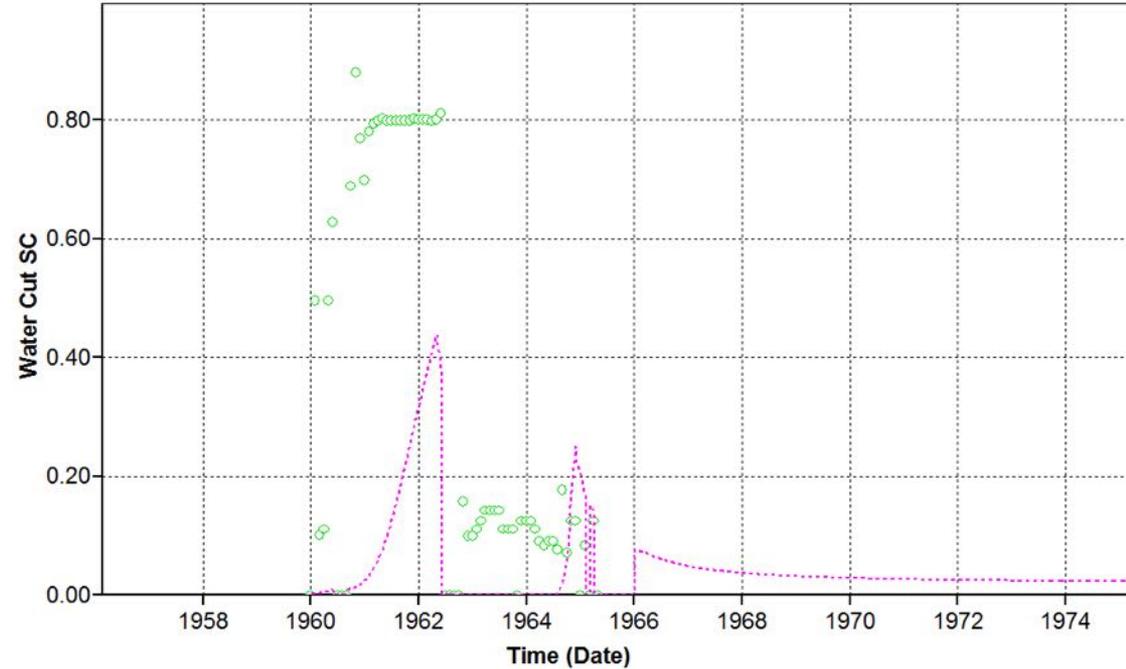
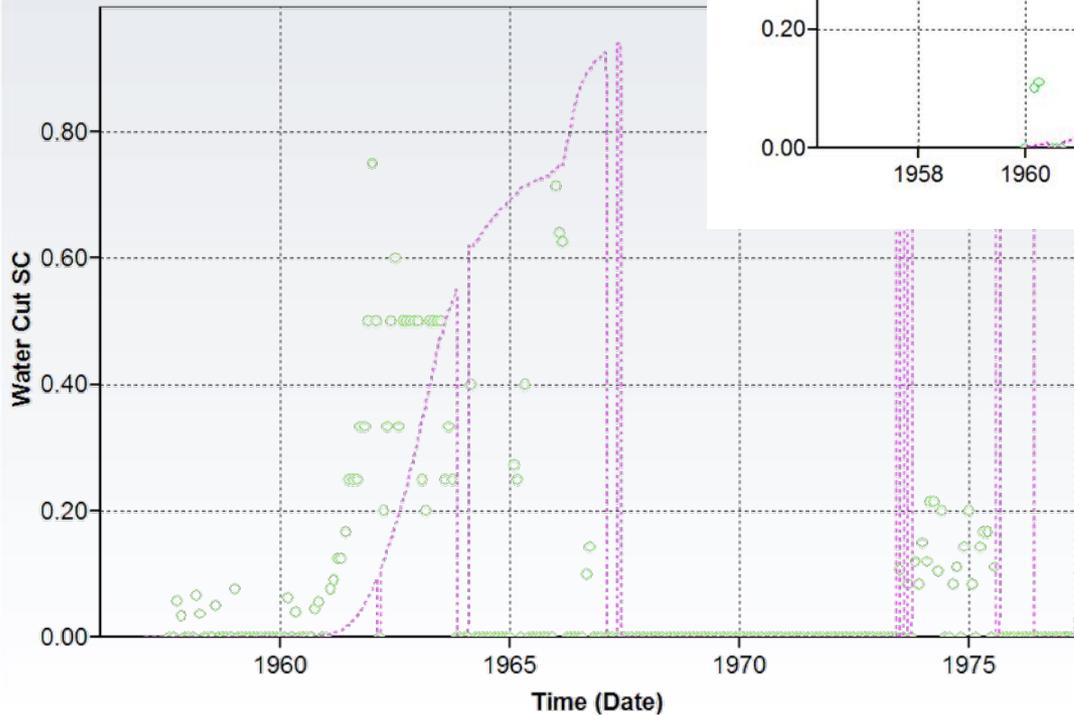
Finilising activity in full 3D model

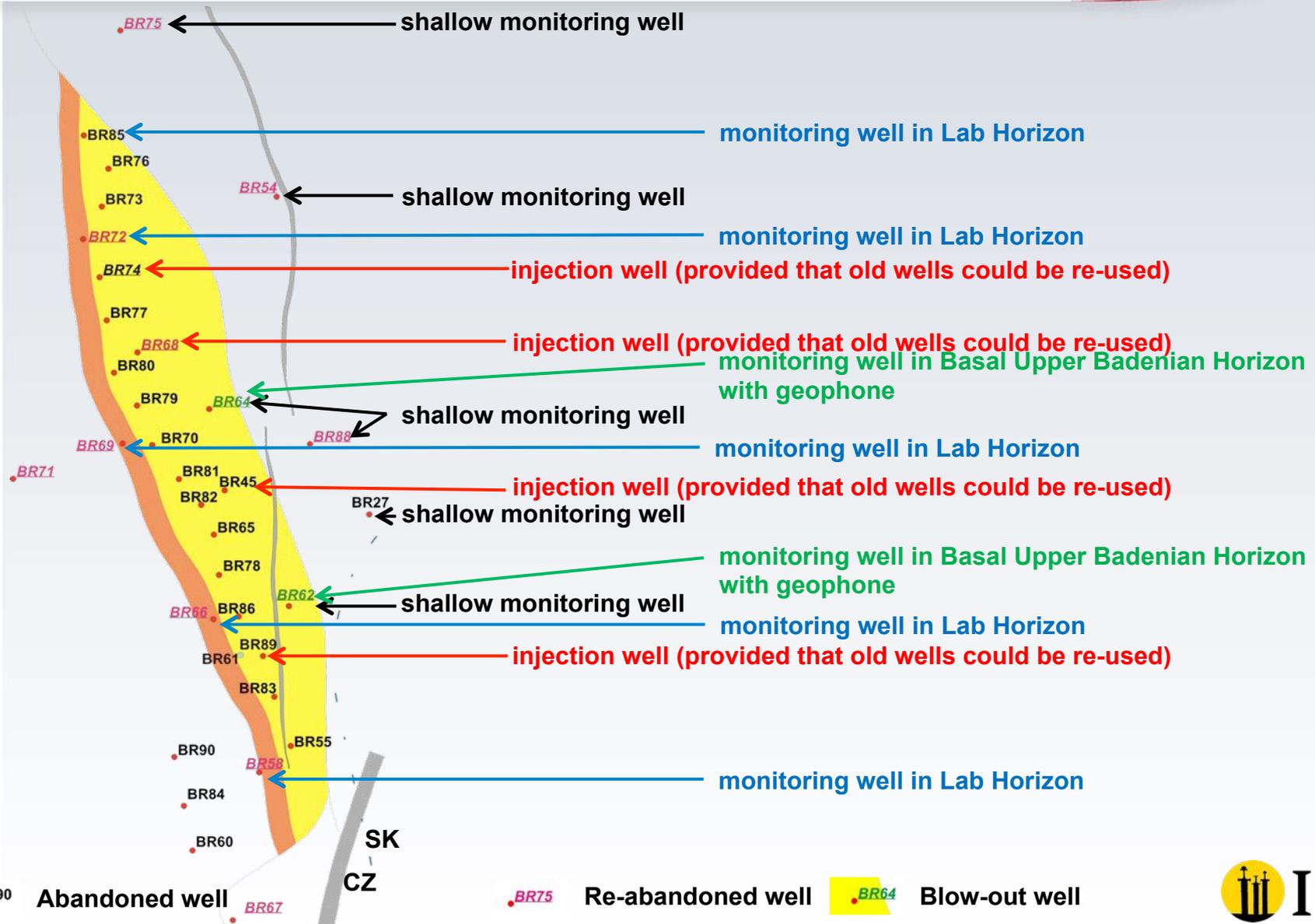


Field-PRO BR_160428.irf



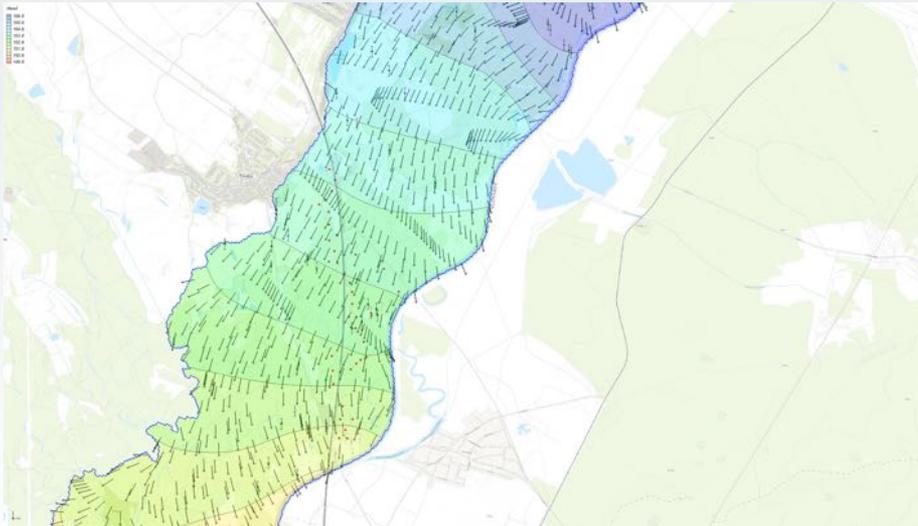
History: well examples





Leakage paths?

- Old wells, faults, cap rock integrity failure
 - Reservoir simulation model to evaluate risks and rates
 - Chemical models to evaluate CO₂ reactivity and elements on its path (rock? Cement? Salts in water?)
 - Detailed surface model to analyze migration of pollutants.



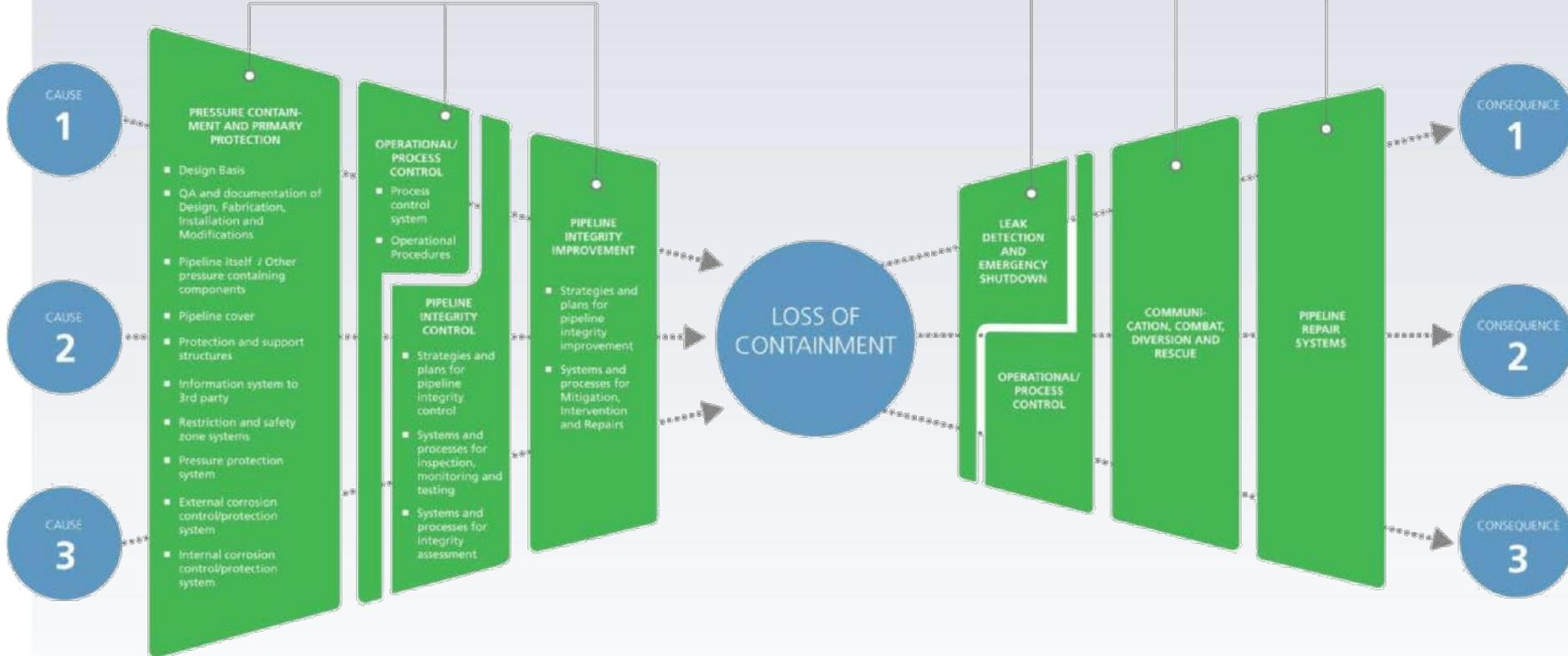
Next stage: risk

Prevention: pro-active

Mitigation: re-active

Barriers to prevent hazardous event

Barriers to control consequences and effects



Reliability

Vulnerability