Near Wellbore Sealing in the Becej CO_2 Reservoir: Field Test of a Silicate Based Sealant

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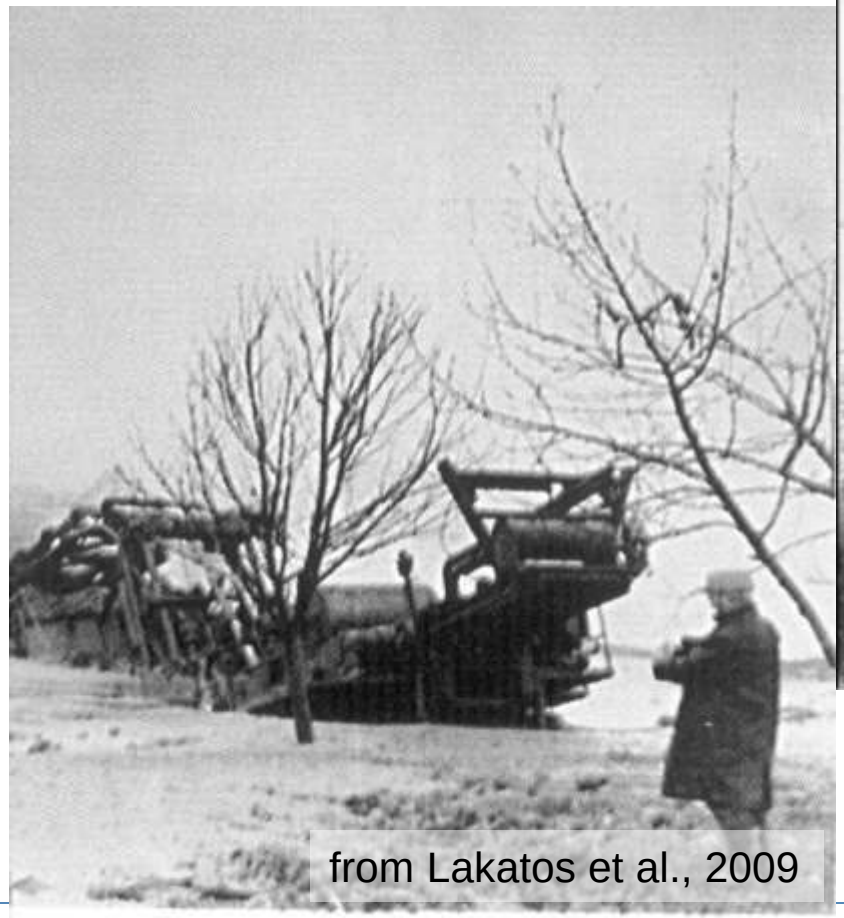
Geology Bečej

- One of the largest natual CO_2 reservoirs in Europe
- Commercial usage for beverage Industry and Linde Gas
- CO_2 Blowout during drilling works in 1968

Blowout 1968

Eight month until collapse of borehole

from Lakatos et al., 2009



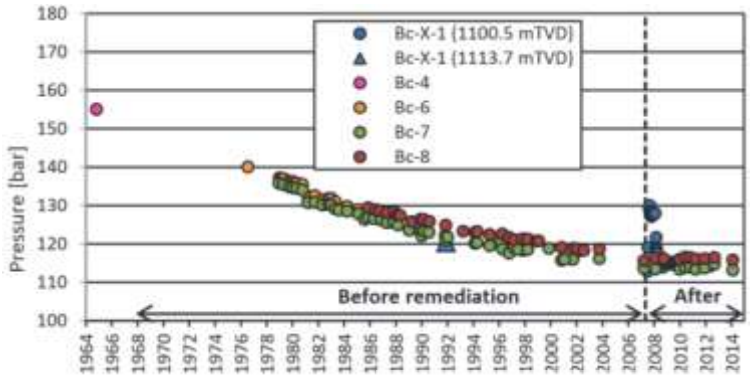
from Lakatos et al., 2009

Spouting and crater formed after borehole collapse


BEČEJ, 10 aprila 1969. god.

Geology

- Pressure decrease until remediation 2007
- 12 m thick sandstone with mainly CO_2 and CH_4 gas



Karas et al., 2016

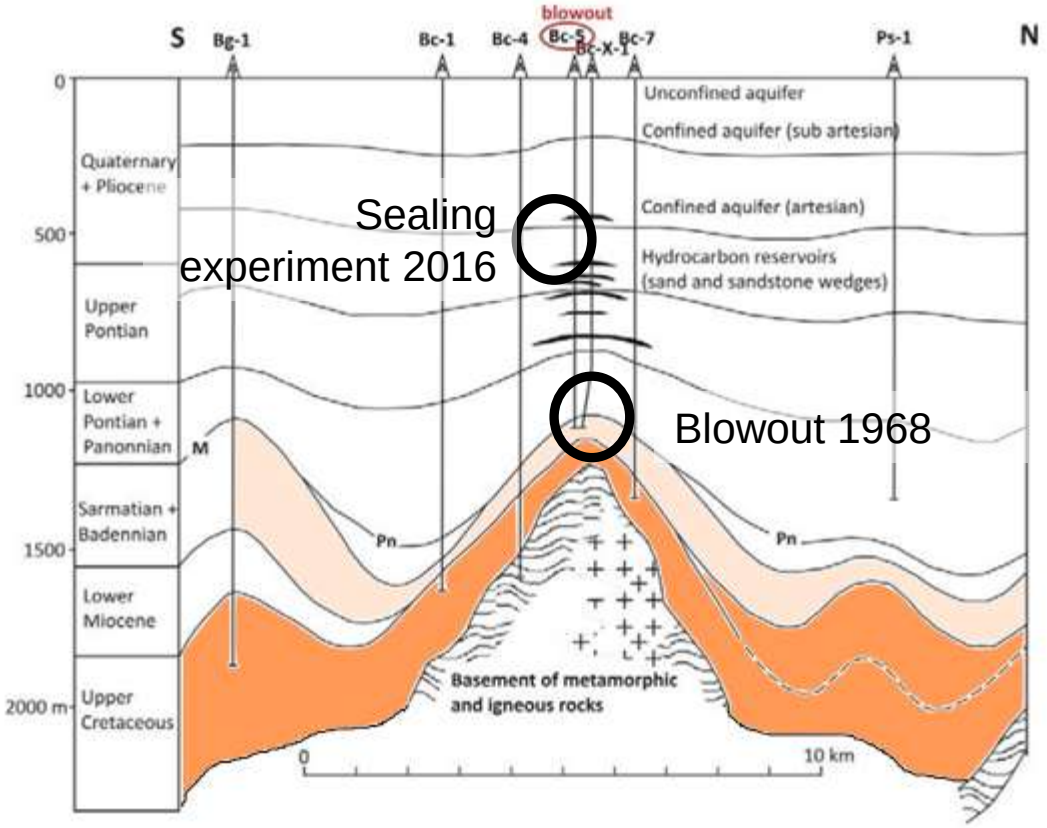
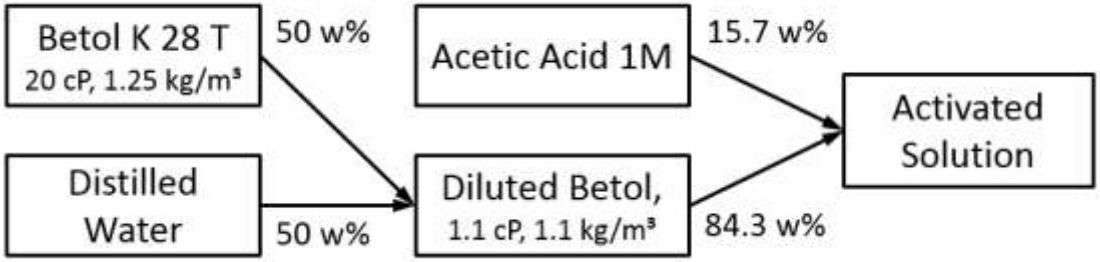


Fig. 2. South-north regional geological cross-section of the Bečej field (Bačko Gradište-Bečej-Banatsko Petrovo Selo) [5].

New Sealing Material

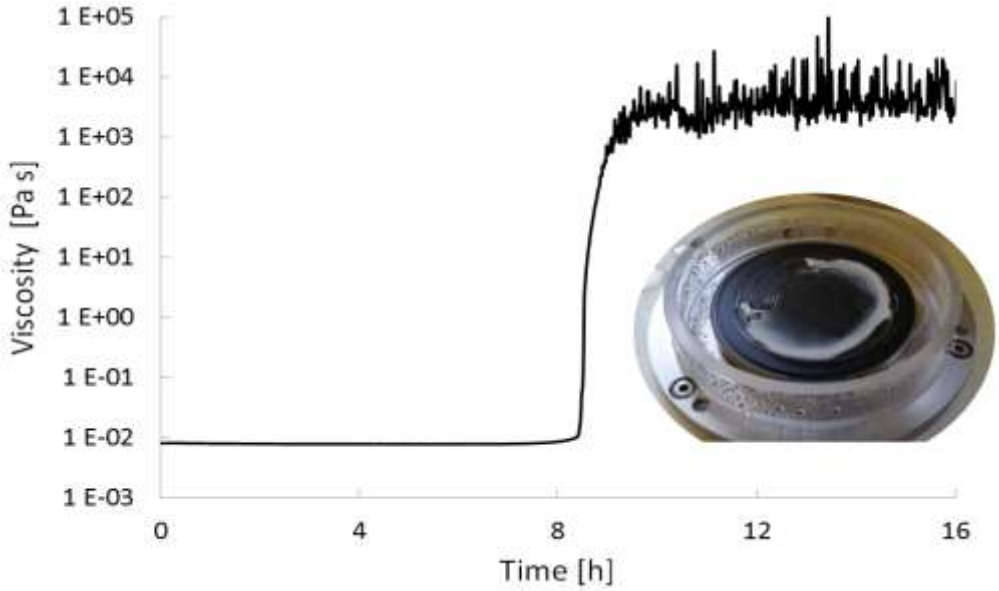
- Successfull remediation with a sophisticated silica-reinforced polymer gel, requires alternate injection of polymer, a cross linker, an alkaline silicate solution, urea and a spacer (Lakatos et al., 2009
- New, simpler sealant with different application profile is developed
- Mixing of commercial silica Betol K28 T and acetic acid



- Distilled water may be fresh water, tap water

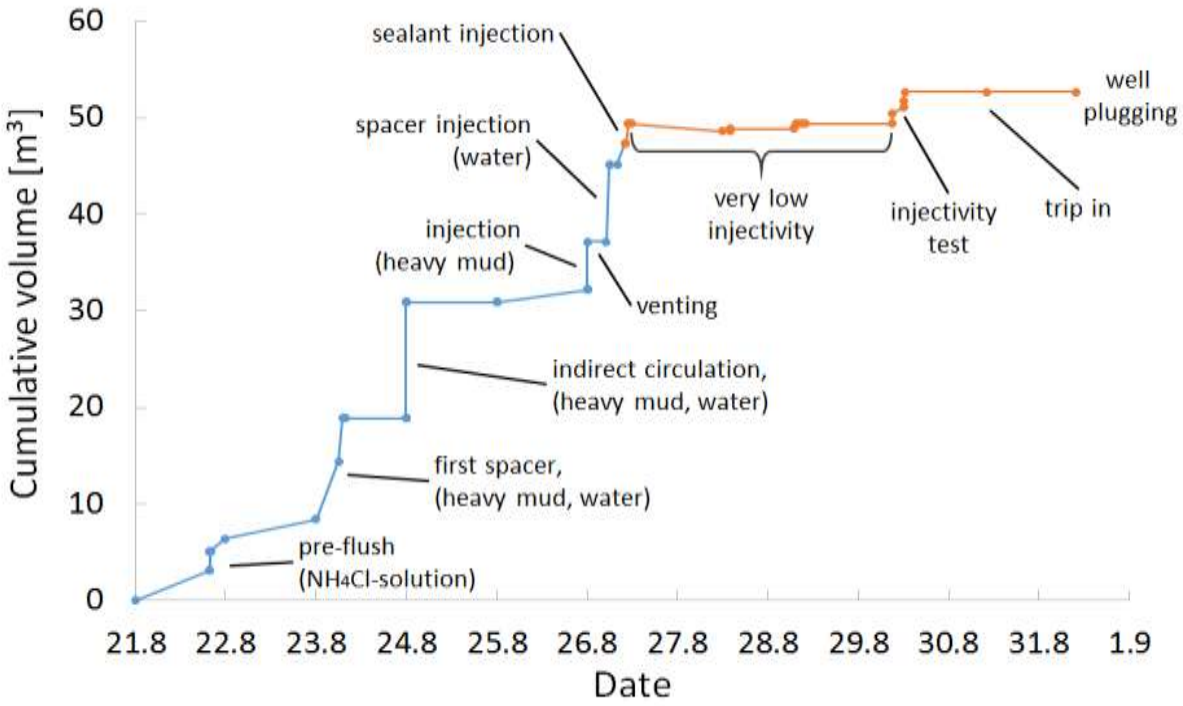
Chemical Formulation

- Low, water like vicosity during long time
- Two gelation reactions
  - Temperature dependent polymerisation
  - Rapid polymerisation in contact to CO_2
- Gel strength 300-600 bar/m
- Extensive studies by IFPEN (Fleury et al., 2017)



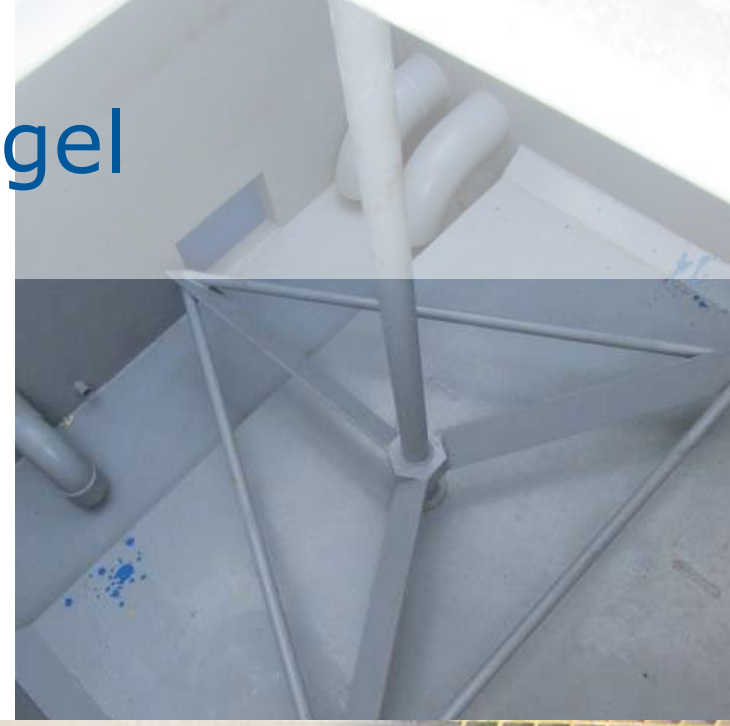
Operational Sequence

- Overwork of the well prior to experiment
- Several flushing and venting operations prior to gel injection
- Key observations:
- No gas was present in the well
- Hydraulic connection to the reservoir fluid remained



Operation

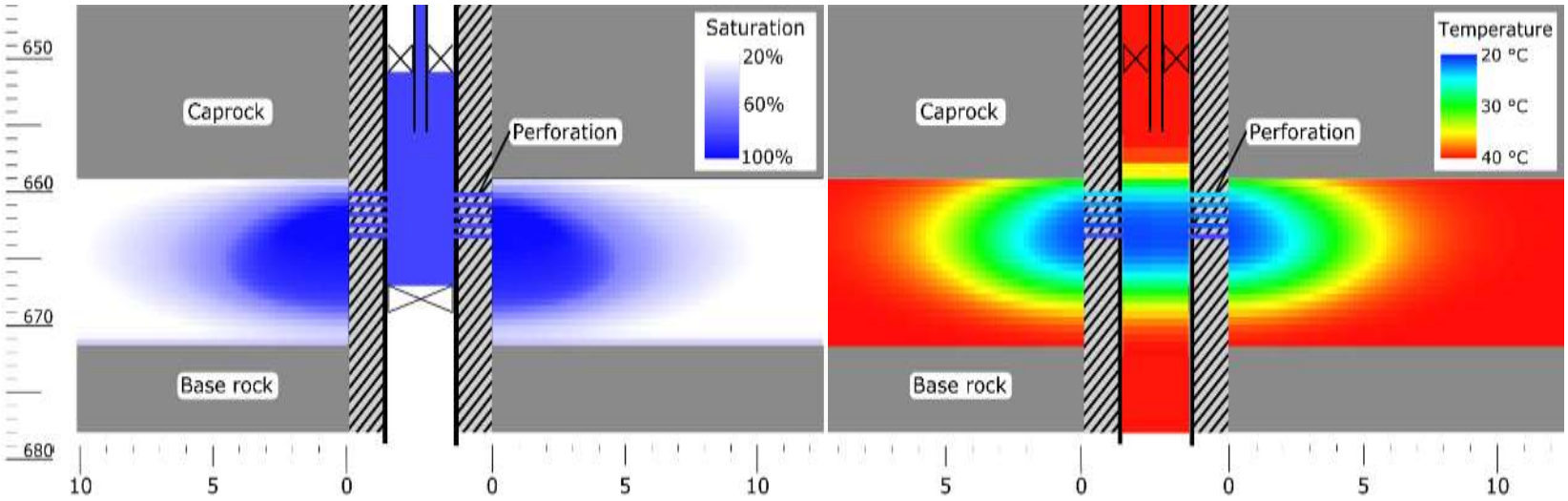
Mixing of the gel



Simulation framework

- Eclipse 300 3D Model
- Simulation of permeability, saturation, temperature, heat exchange
- Simulation of injection sequence
- No explicit simulation of viscosity an permeability changes
- Reservoir without mobile fluid
- Total fluid injection volume of 51 m³
- 2 m³ of gel inected (instead of 8 m³ as originally planned)
- Manual time stepping with temperature simulation, frequent convergence problems

Reservoir before gel injection

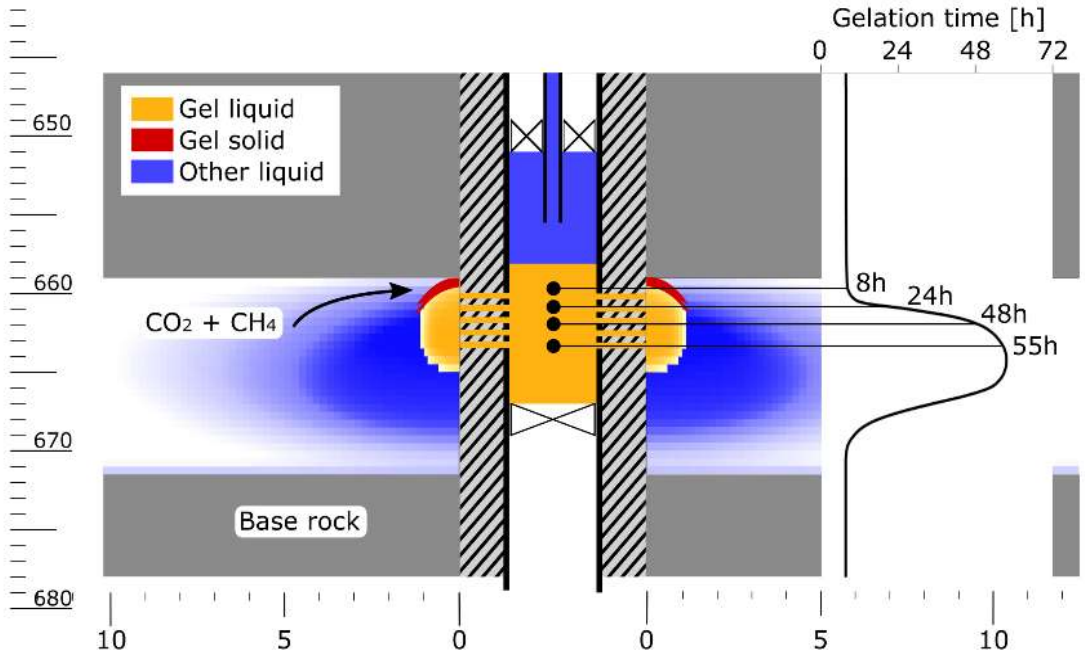


- Fluid distribution
- Fluid bubble around the injection well

- Temeprature distribution
- Reservoir temperature 40 °C,
- Injected fluid 20 °C

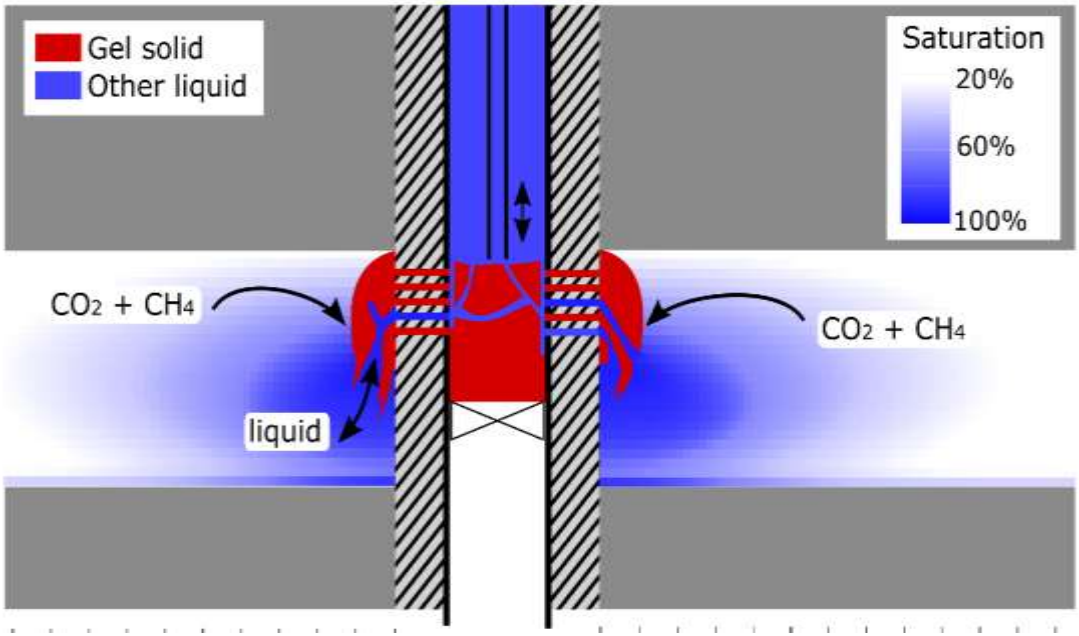
Directly after gel injection

- Fluid distribution after gel injection
- About 1 m radius of gel
- Gelation time depends strongly on position:
- Wellbore vertical profile
- Reservoir horizontal profile
- Reservoir gas contact interface



Explanation after sealing

- T = 72 h after injection
- All gel solidified
- Fluid bubble moving slowly downward due to gravity
- Open pathways to the reservoir fluid remains
- Possible reasons:
- dilution due to fluid movement
- Uneven disdtribution due to heterogeneities
- Potentially syneresis due to salt water (ulikely with fresh water after 72 h)



Evaluation of Objectives

Goal	Criterion	Result
Upscale fluid mixing in the field	Homogenous, low viscosity, no flocculation	Achieved in second attempt
Avoid gelation in open borehol	Normal well circulation possible	Achieved
Place seal in formation	Presence of residual gel plug in open hole	Achieved
Seal formation	No hydraulic contact between well and reservoir	To gas achieved, open to fluid
Long-term sealing performance	No influx during monitoring	Only five days of monitoring

Conclusion

- Successful sealing of the reservoir layer against gas with low gel volume (2m³)
- Short term sealing capacity is proven
- Selective fast reaction with CO_2
- Slow reaction by acid and temperature activation
- Very low, water like viscosity enhances applicability
- Gel susceptible to syneresis (shrinking)

Open questions

- Different reaction pathways with CO_2 and with acid, different reaction products?
- Impact of saline water?
- Impact of Heterogeneity?


Questions