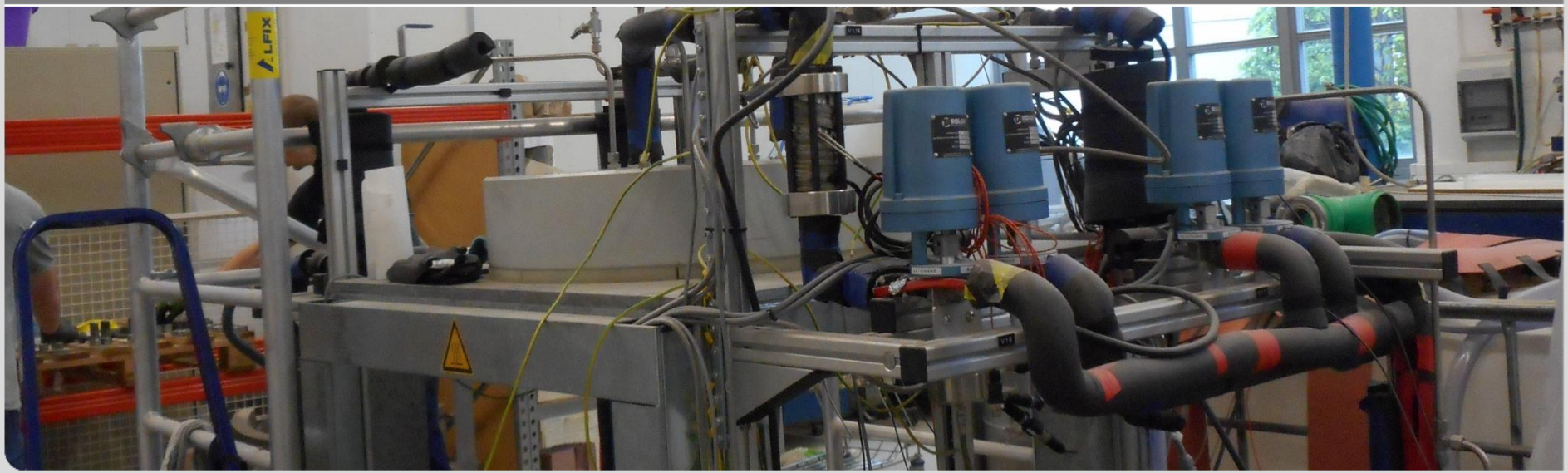
Karlsruhe Institute of Technology

Large Scale Experiments on the Tightness of Boreholes under Cyclic Loading

Marcel Schulz

Division of Technical Petrophysics
Institute for Applied Geosciences



Topics

- Experiments with Smaller Apparatus
  - Setup
  - Reconstruction
  - Model & Results

- Description and Potential of Large Apparatus
  - Setup & Specifications

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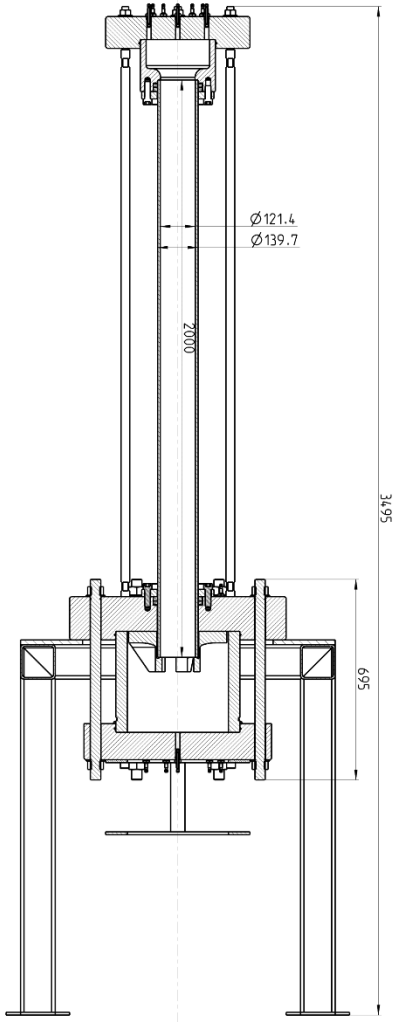
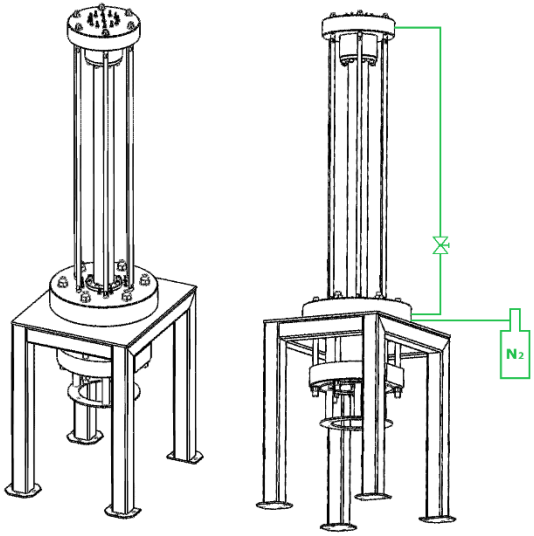
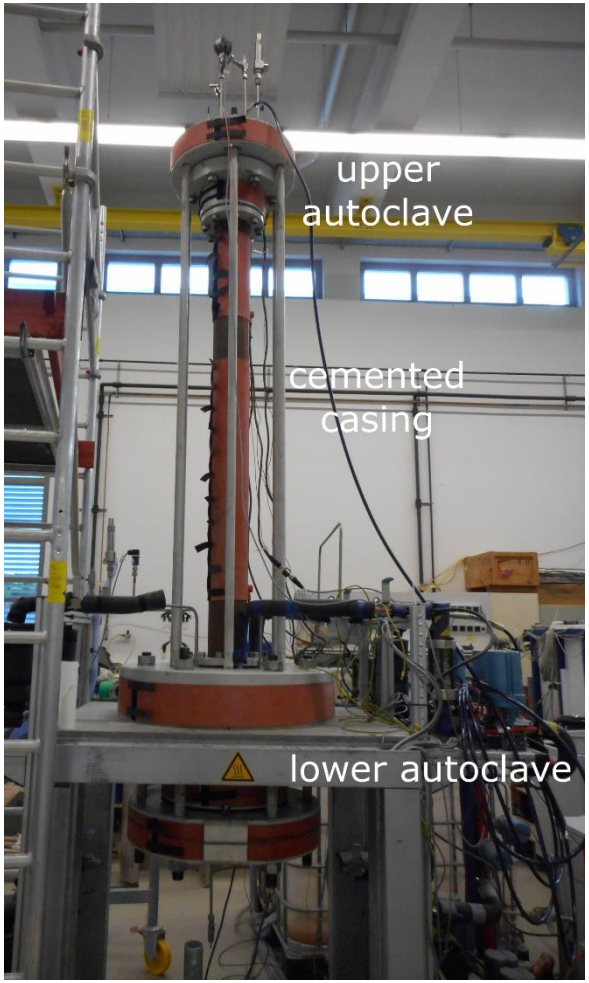
The smaller Apparatus



- Casing filled with cement
- How does the tightness of the cemented casing respond to cyclic loading (P/T variation)?





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Reconstruction

Reconstruction

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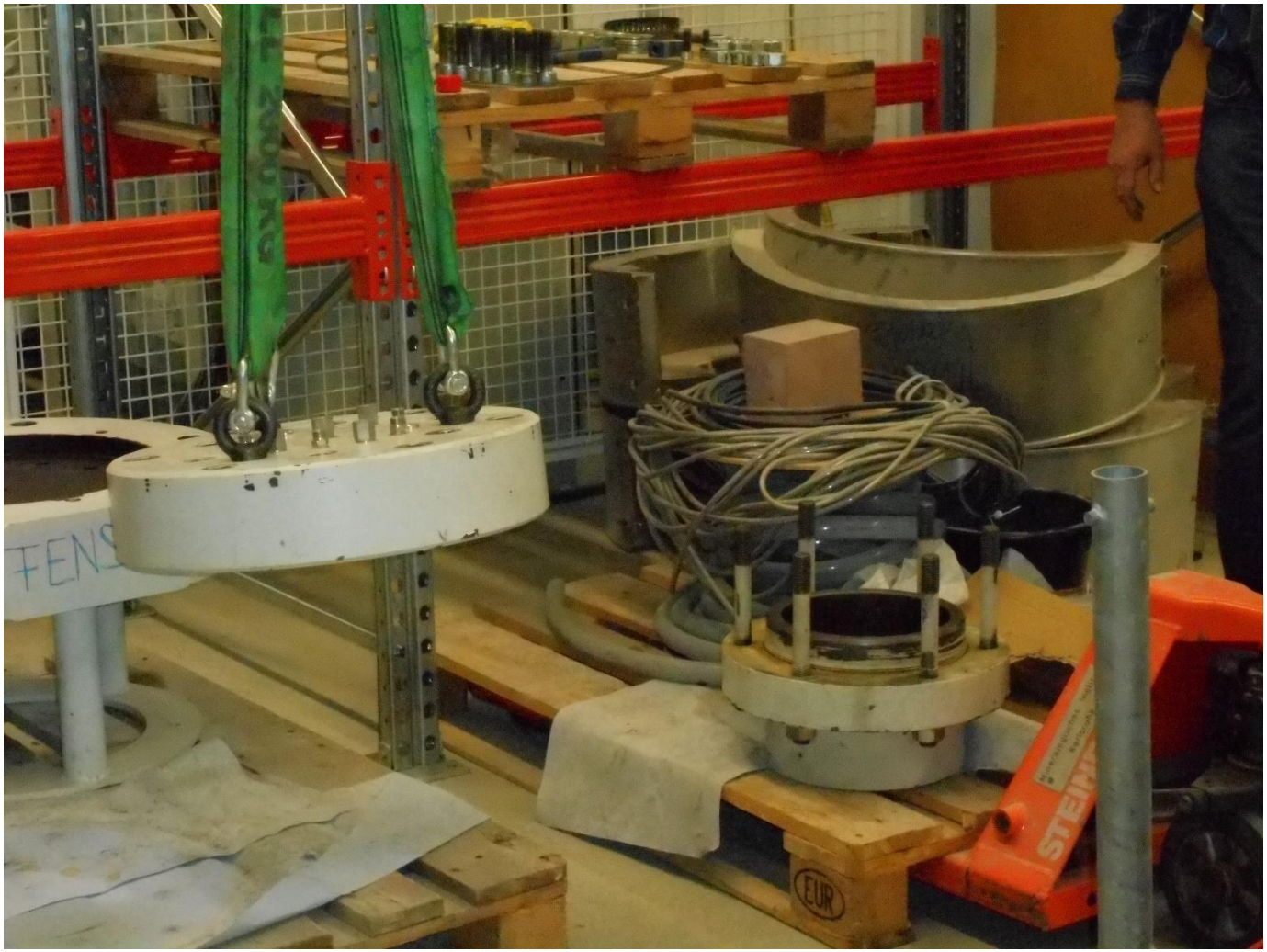

Reconstruction

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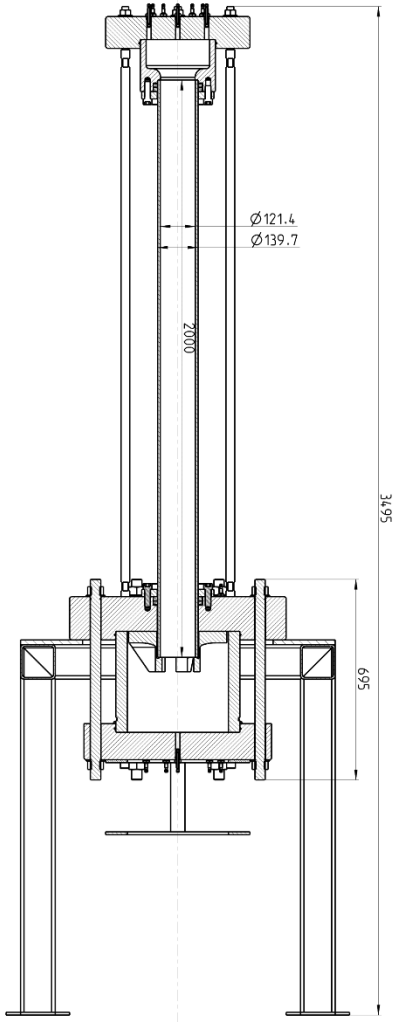
The smaller Apparatus



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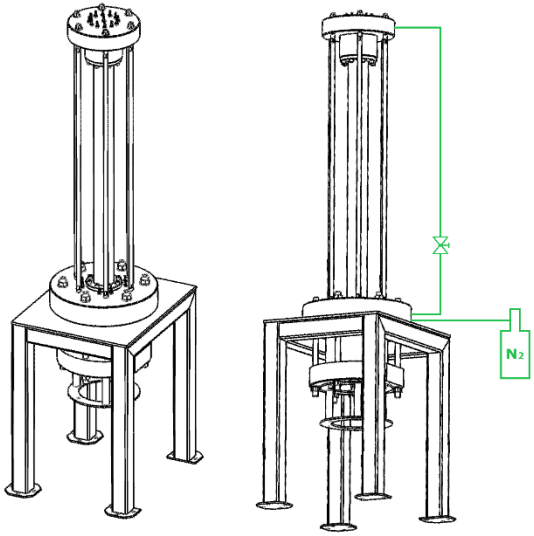
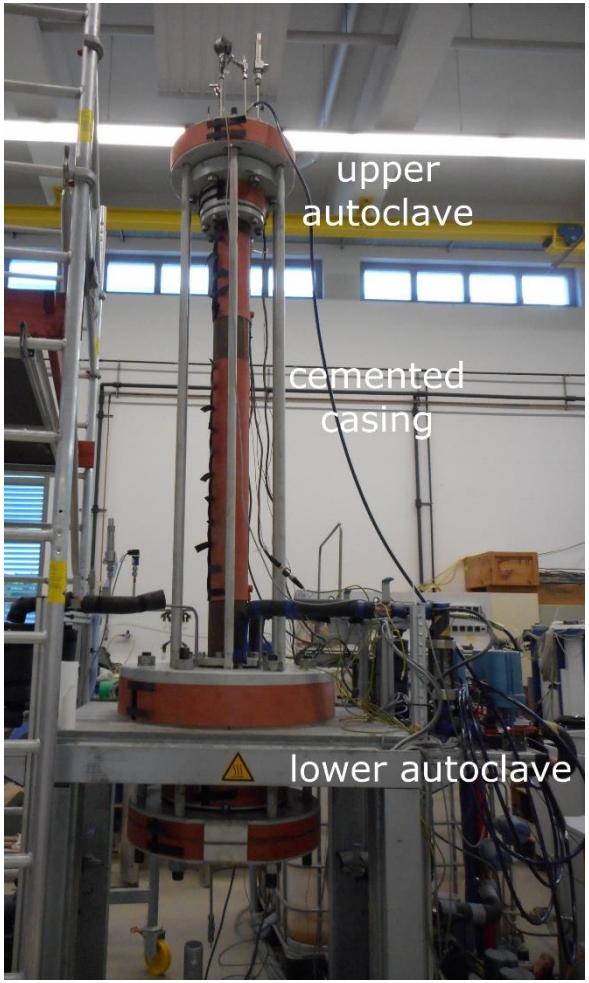
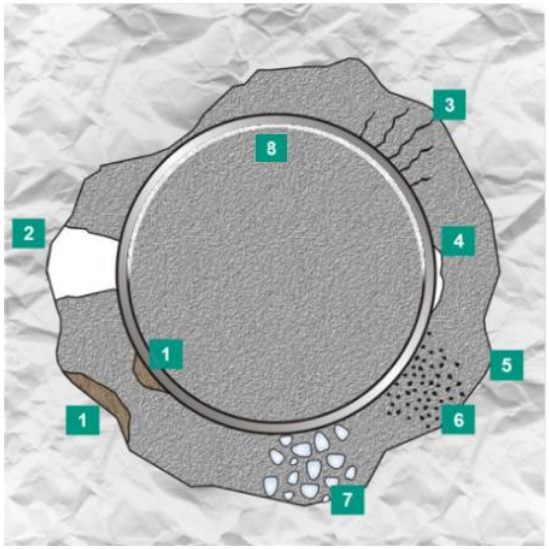
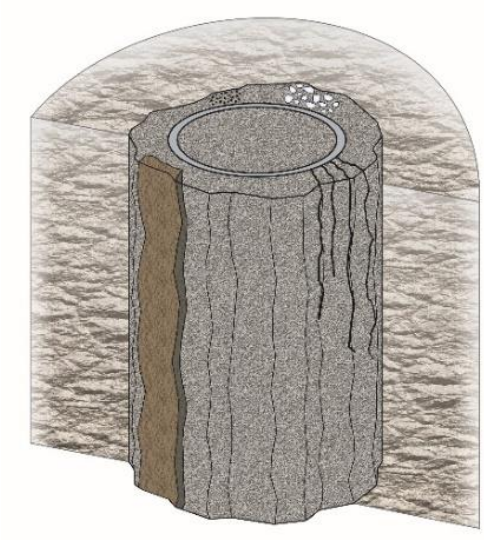




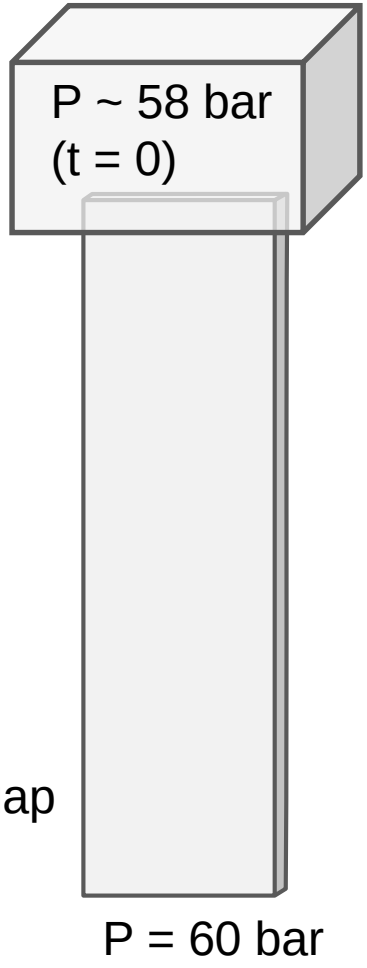
Model

- Different paths for gas possible, focus on annular gap (8)





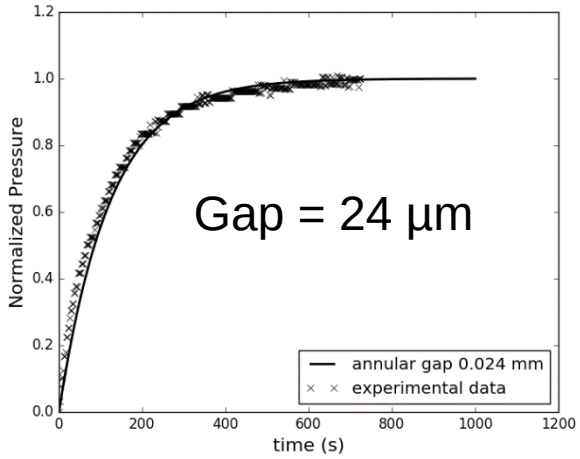
Modified after: Kromer M, Haist M, Müller HS (2014) Formation mechanisms of cementation flaws in well cementations under consideration of paste rheology. In: Bastien J, Rouleau N, Fiset M, Thomassin M (ed) Proceedings of the 10th fib international PhD symposium in civil engineering, Université Laval, Quebec.

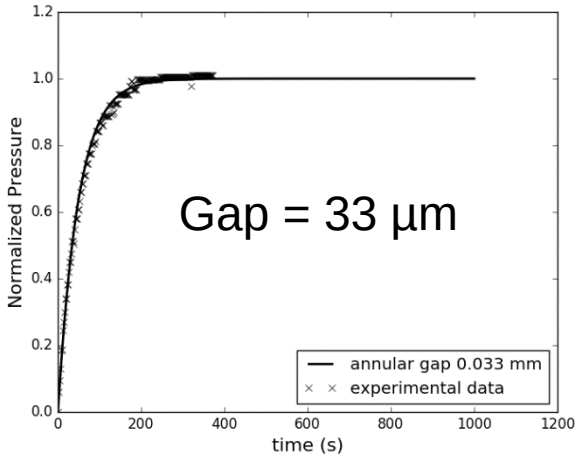


- Model of pressure evolution with time through a (straightened) gap
  - Lower boundary condition: 60 bar, $t \geq 0$
  - Upper boundary condition: 60 bar - released pressure, $t = 0$
  - Flow based on Hagen-Poiseuille

Model

- Model of pressure increase in the upper chamber:
  - Dots are normalized pressure data
    - only pressure increase after pressure release is examined
  - Fitting curve based on Hagen-Poiseuille



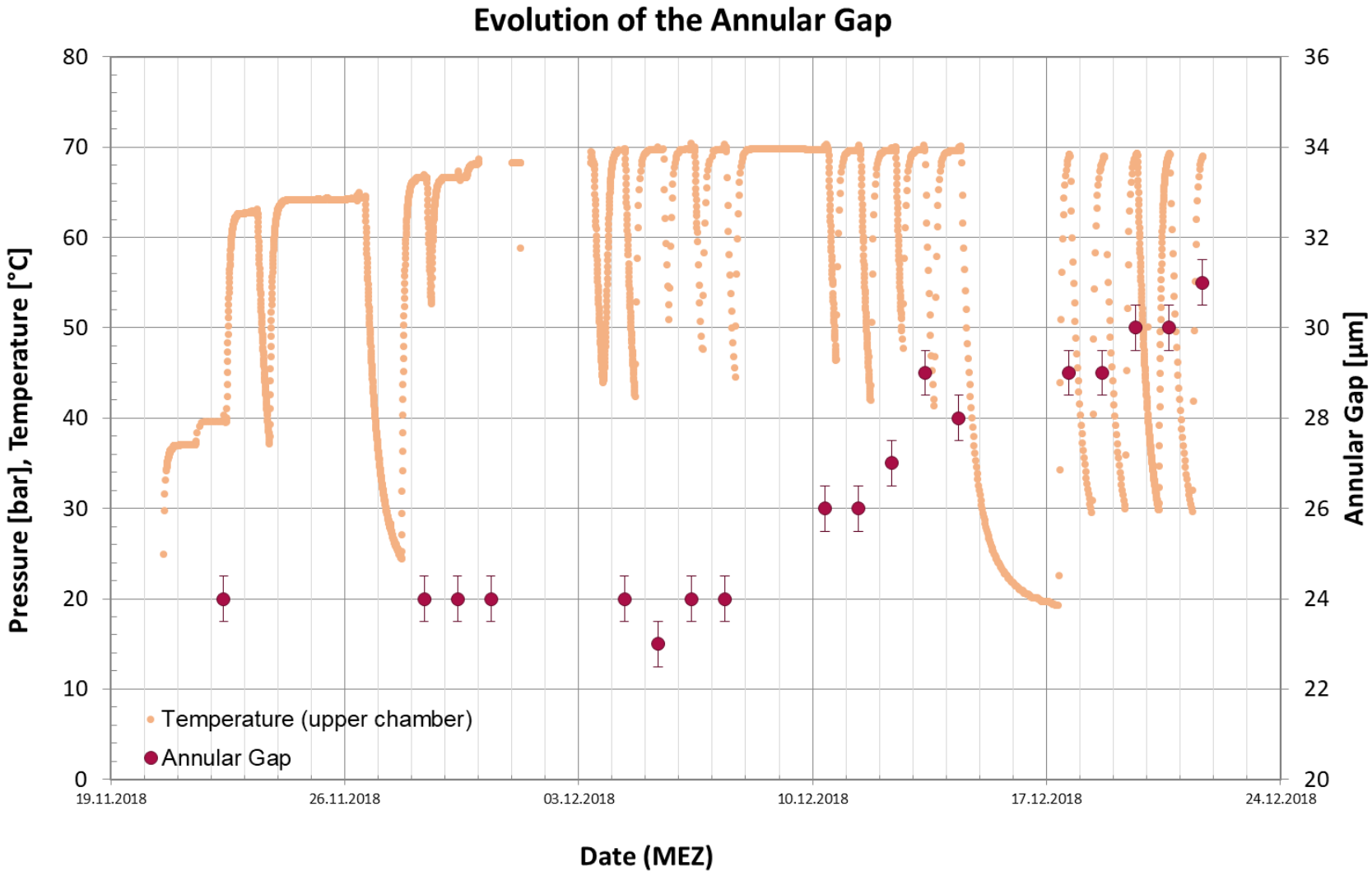


$$P_{norm} = \frac{P - P_{min}}{P_{max} - P_{min}}$$

- Hagen-Poiseuille: Width of the gap goes into equation with exponent 3

$\frac{33^3}{24^3}$ = 2.6 → gap widening of 37.5 % increases volumetric flow by 160 %.

Preliminary Results



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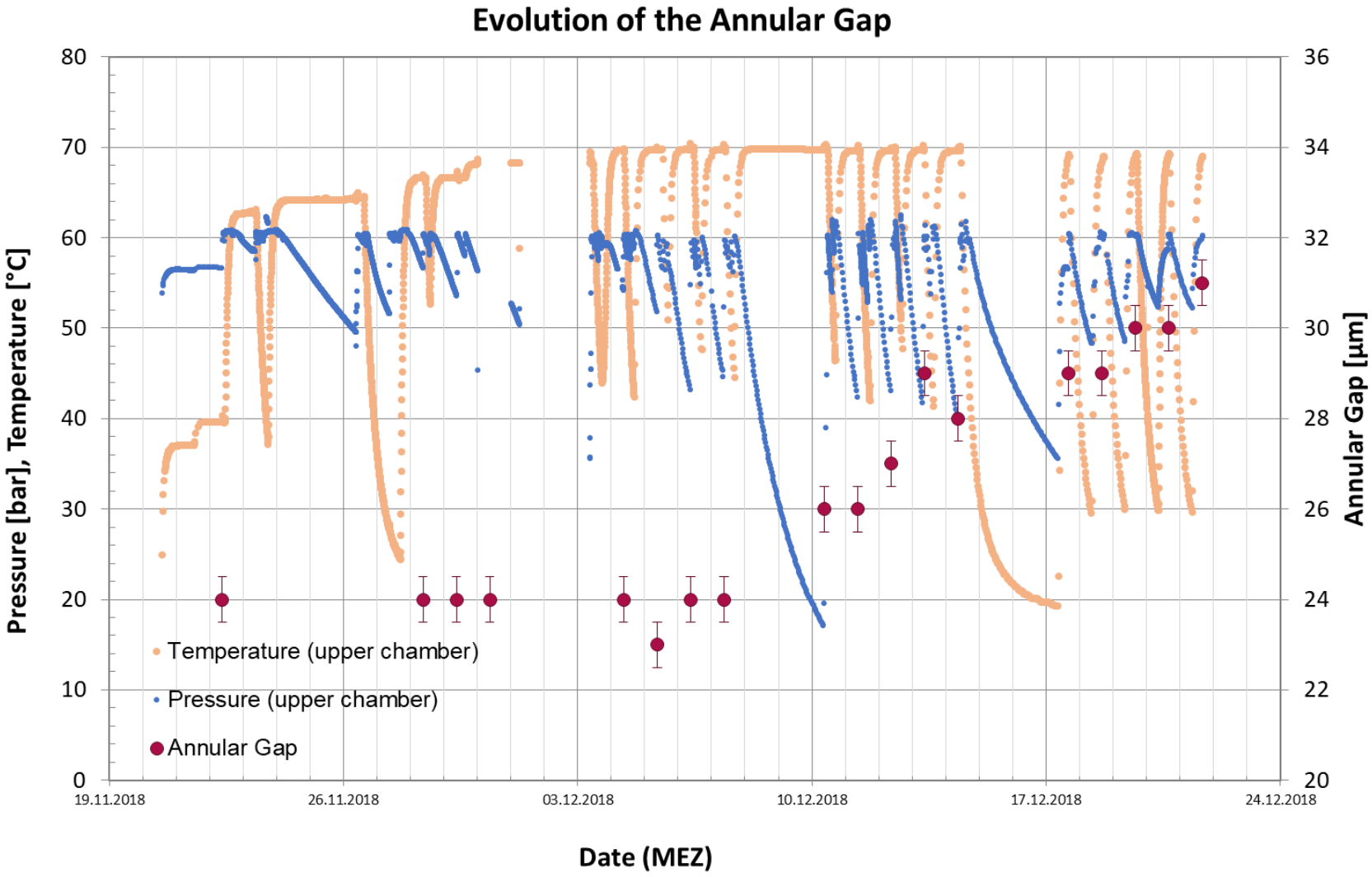
Preliminary Results



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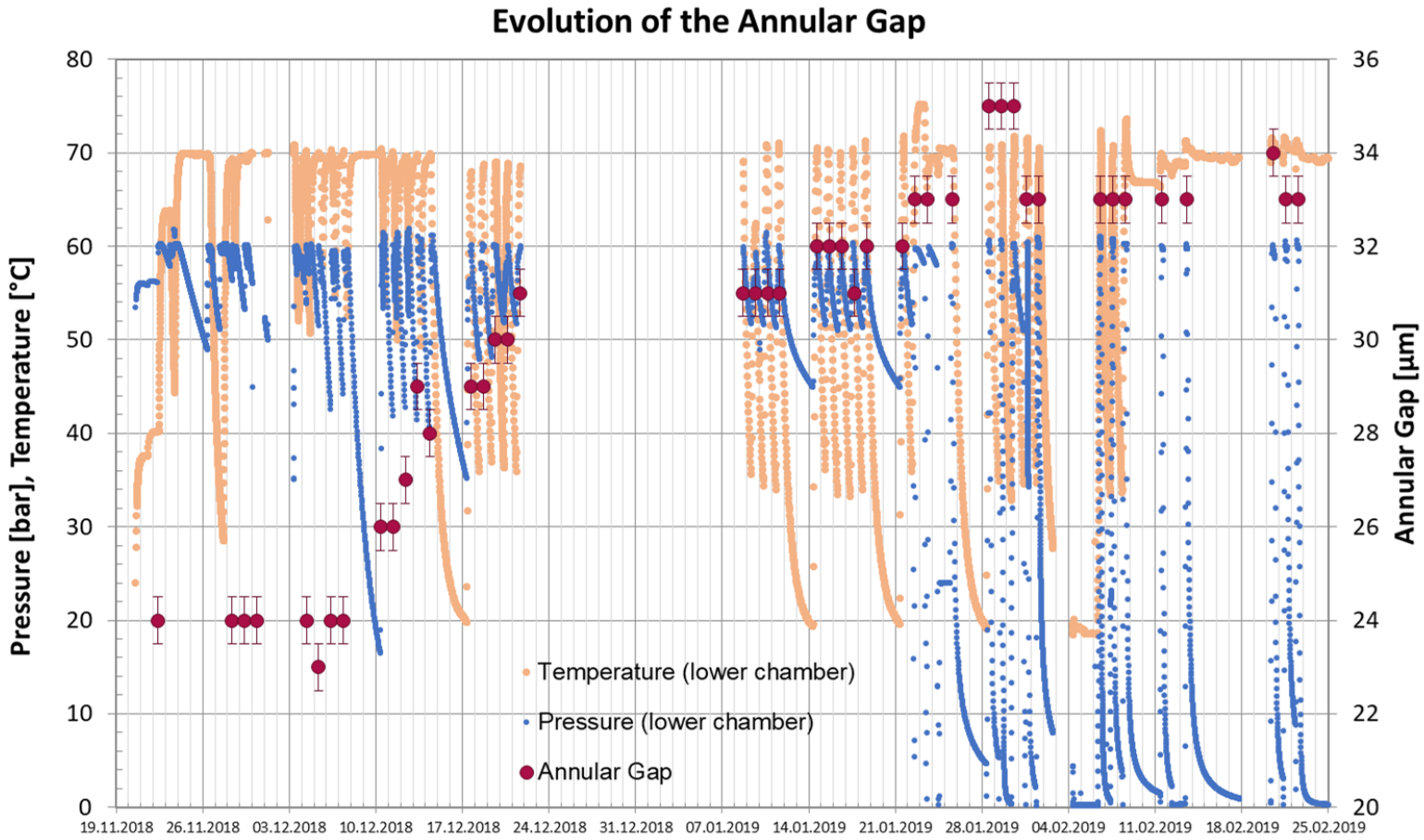
Preliminary Results



T	P	Gap Increase
var.	const.	no
var.	var.	yes
const.	var.	?

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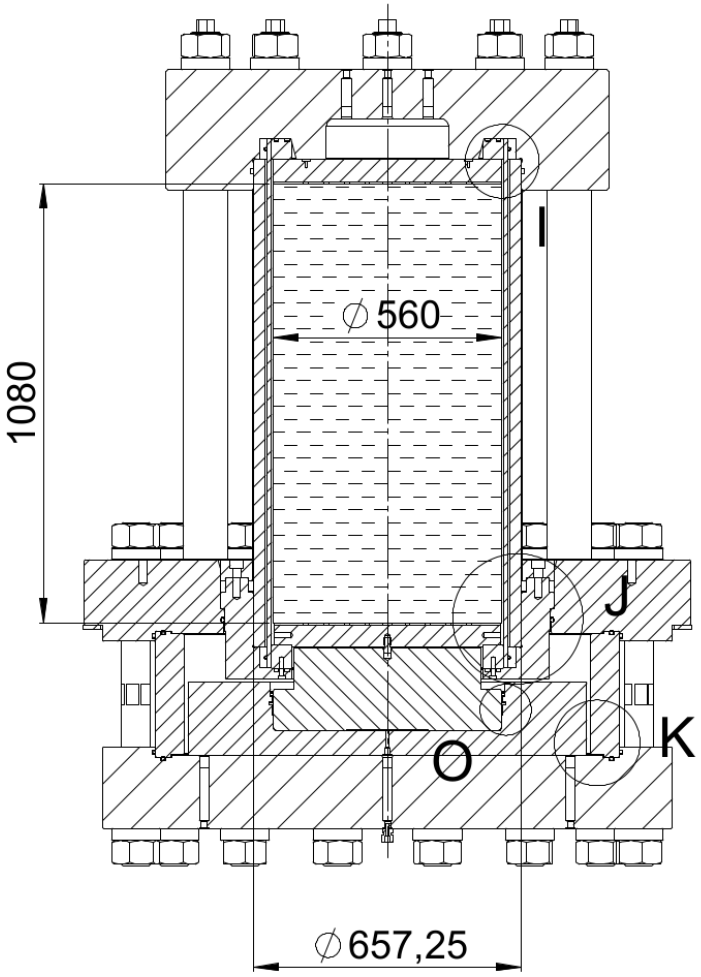
The large apparatus



Specifications of the large apparatus

- T_{max} = 100 °C
- P_{Pmax} = 70 bar

- Cylindric rock sample (Ø 560 mm)
  - With drilling inside
  - Cemented casing inside drilling

- Currently under reconstruction
  - Axial pressures of up to 120 bar
  - Confining pressures of up to 80 bar

Thank you for your attention!