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Investigation of Hydraulic Fracture Re-Orientation Effects in Tight Gas Reservoirs

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OUTLINE

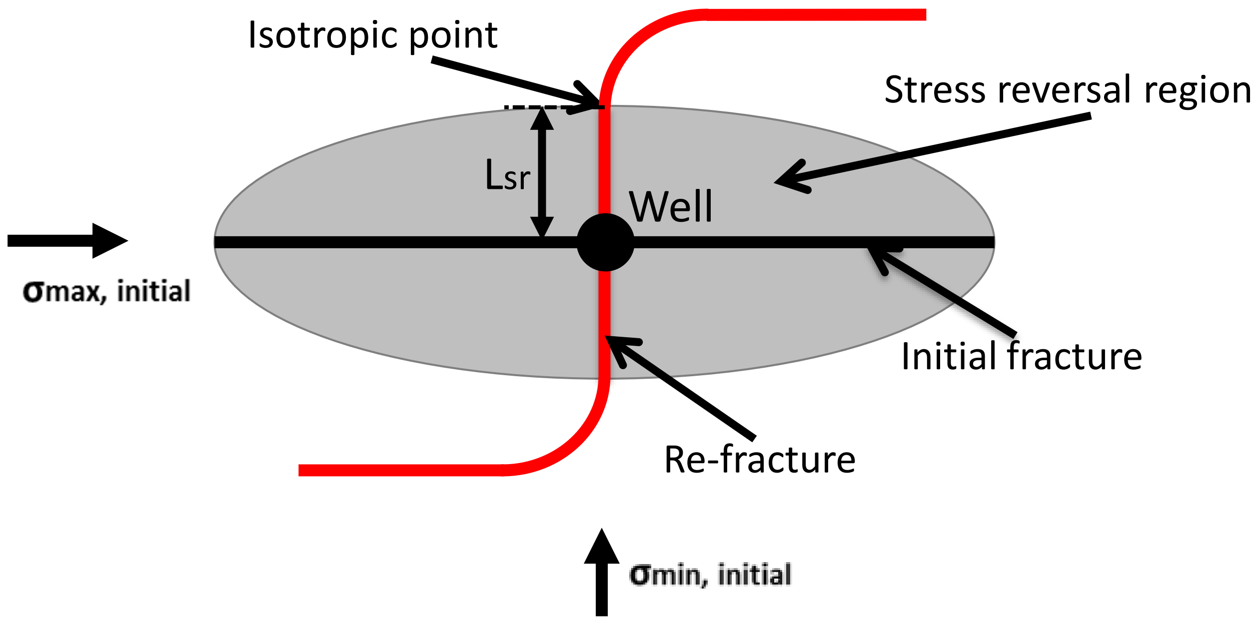
- RE-FRACTURING CONCEPT IN TIGHT GAS RESERVOIRS
- IMPLEMENTATION IN COMSOL
- NUMERICAL SIMULATION
  - BASE CASE SIMULATION
  - IMPACT OF PERMEABILITY
- CONCLUSIONS

RE-FRACTURING CONCEPT IN TIGHT GAS RESERVOIRS

- Low matrix permeability in tight gas reservoirs
- Hydraulic fracturing required for economic production rates
- Production from the well and its initial fracture declines
- Re-fracturing required to accelerate recovery
- Field cases show different orientation of re-fracture
- Connection to a less depleted region in the reservoir

RE-FRACTURING CONCEPT IN TIGHT GAS RESERVOIRS

- Concept of stress reversal during pressure depletion



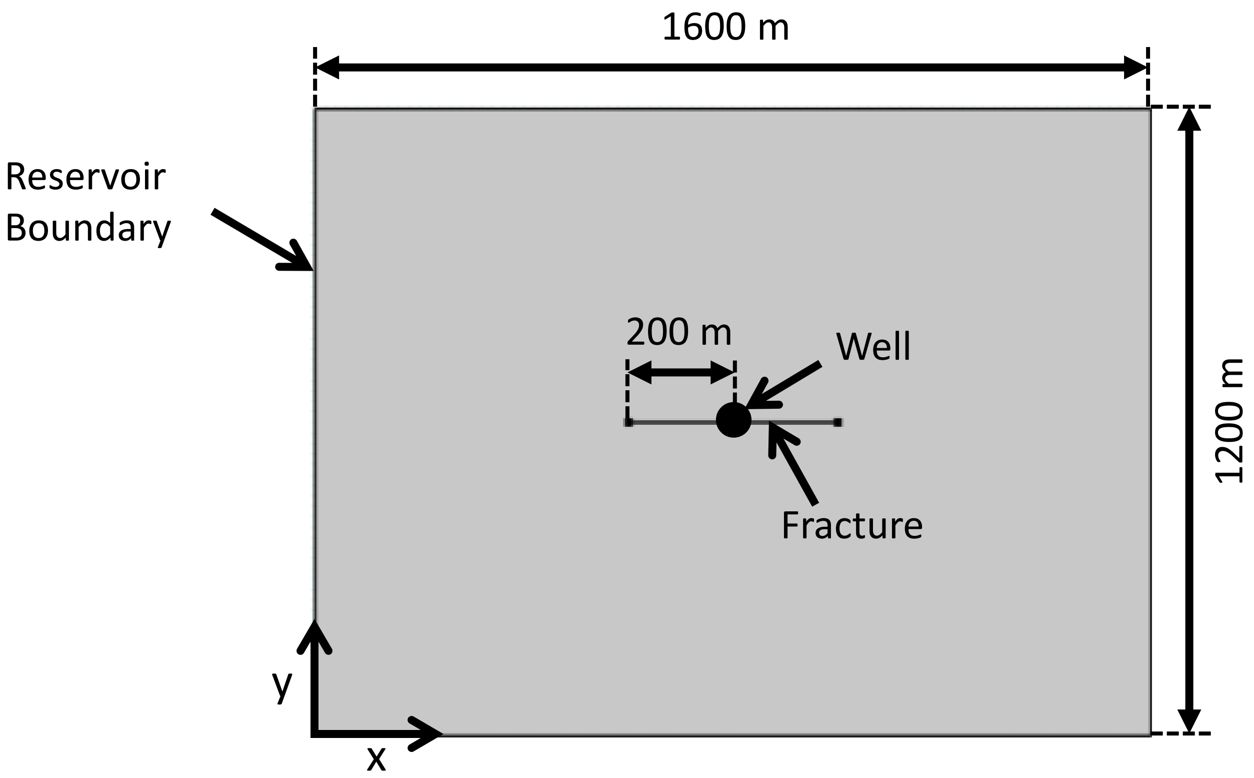
(Redrawn after Siebrits and Elbel, 1998)

RE-FRACTURING CONCEPT IN TIGHT GAS RESERVOIRS

- Is the re-fracture orientation predictable?
- How far does the re-fracture propagate into the perpendicular direction?
- What is the best time for re-fracturing?
- Which parameters influence the propagation?

➢ Set up of numerical reservoir model in COMSOL Multiphysics
  - Coupling of fluid flow and geomechanics
  - Use of “Poroelasticity” physics interface

IMPLEMENTATION IN COMSOL – Geometry



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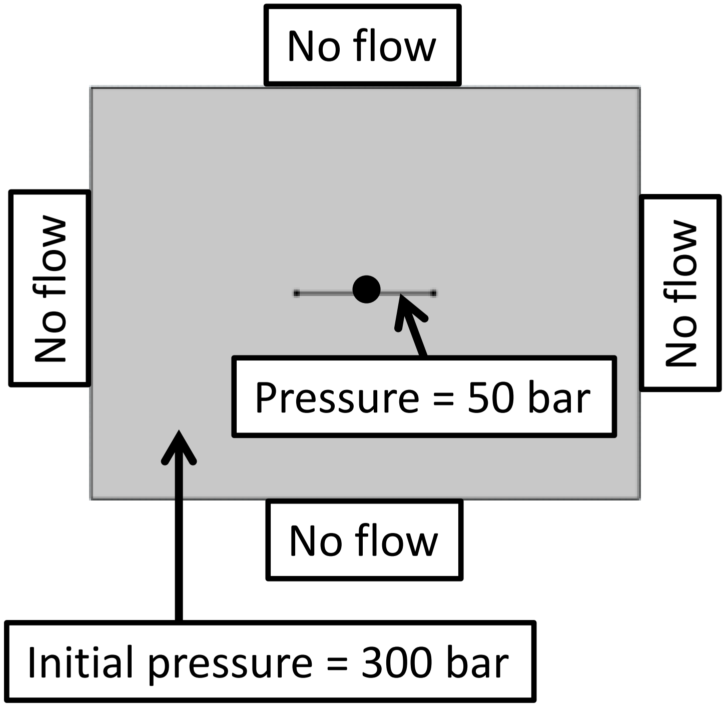
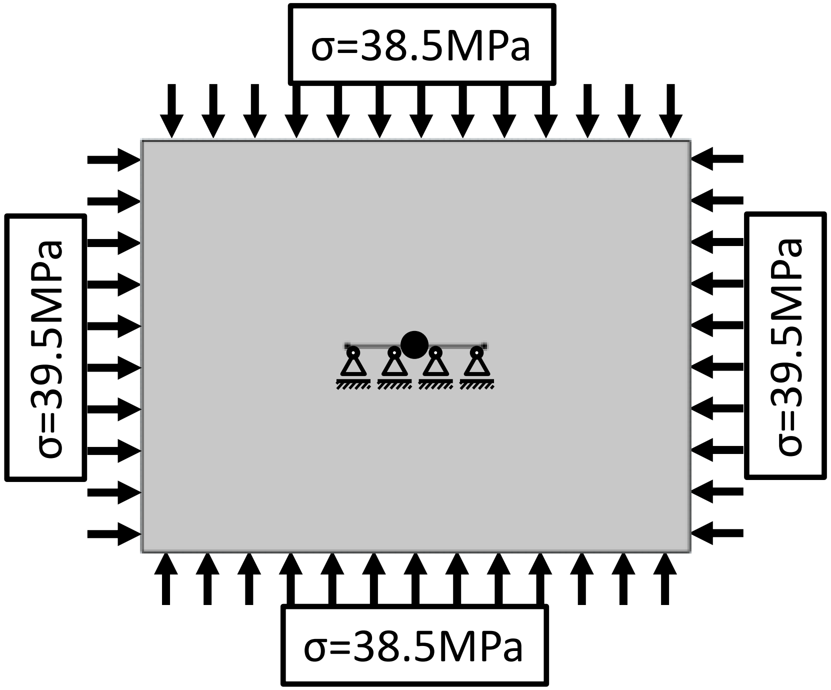
IMPLEMENTATION IN COMSOL – Initial and Boundary Conditions

- Fluid flow



- Geomechanics

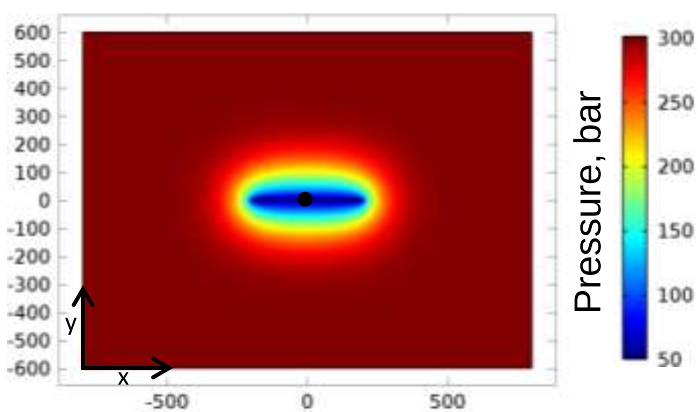


IMPLEMENTATION IN COMSOL – Parameters

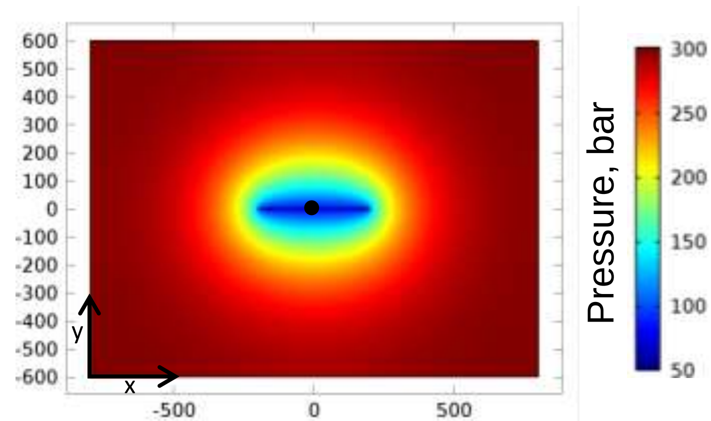
Class	Parameter	Value	Unit
Reservoir Rock	Permeability	0.01	mD
Reservoir Rock	Porosity	0.1	-
Reservoir Rock	Young's Modulus	$2.75*10^5$	bar
Reservoir Rock	Poisson's Ratio	0.25	-
Reservoir Rock	Biot's Coefficient	0.7	-
Natural Gas	Relative Density	0.6	-
Natural Gas	Temperature	110	°C

NUMERICAL SIMULATION – Base Case Simulation

- After one year



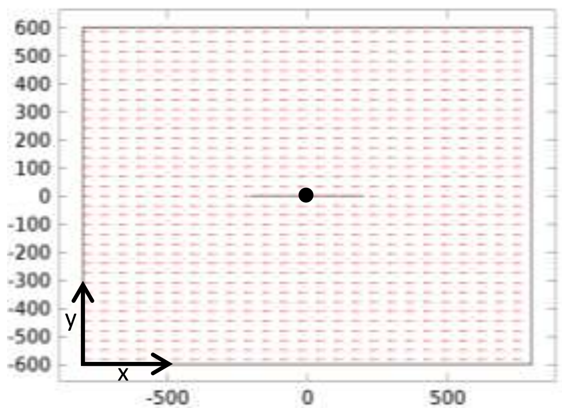
- After five years



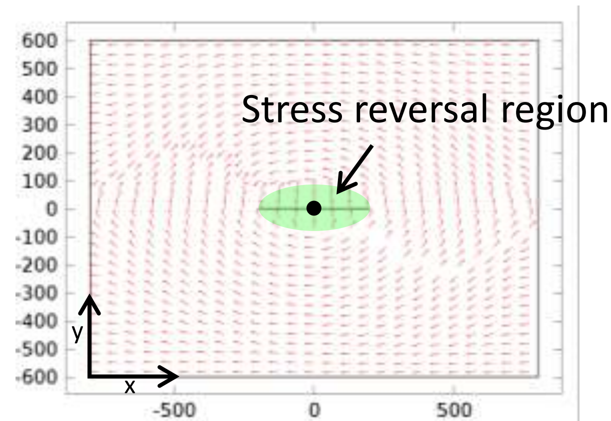
- Elliptical shaped drainage area
- Higher pressure gradient in y-direction in the vicinity of the wellbore

NUMERICAL SIMULATION – Base Case Simulation

- Initial maximum principal stress direction



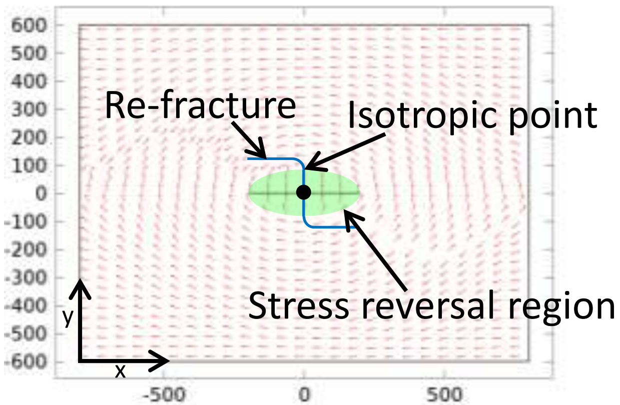
- Maximum principle stress direction after five years

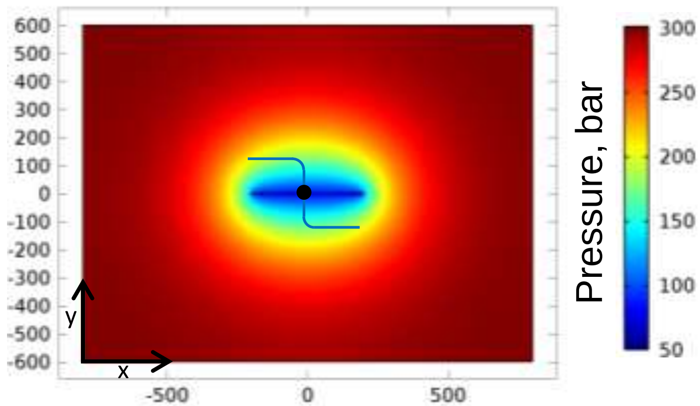


- Elliptical shaped stress reversal region
- Bypassing of stress lines around this region

NUMERICAL SIMULATION – Base Case Simulation

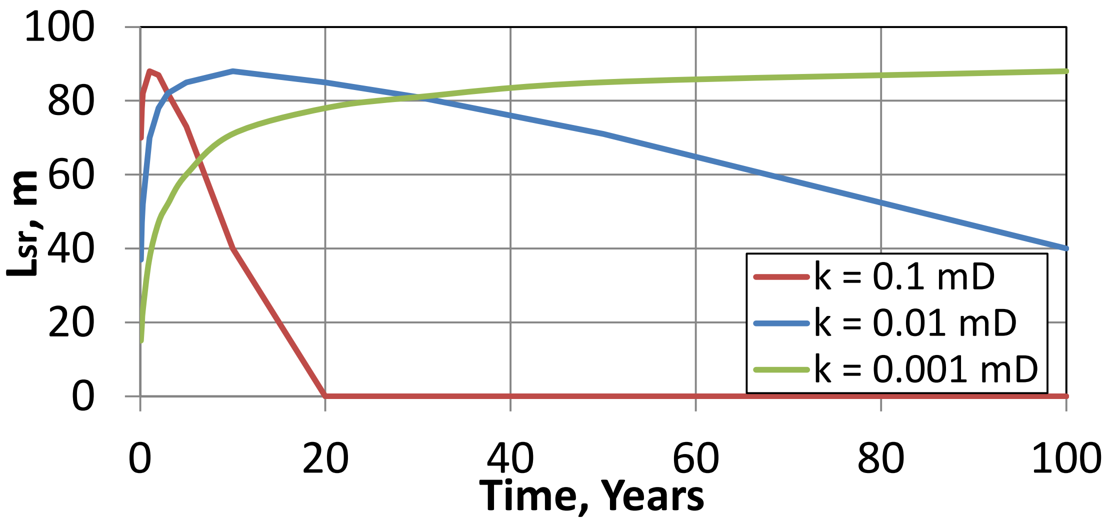
- Maximum principle stress direction after five years
- Pressure distribution after five years

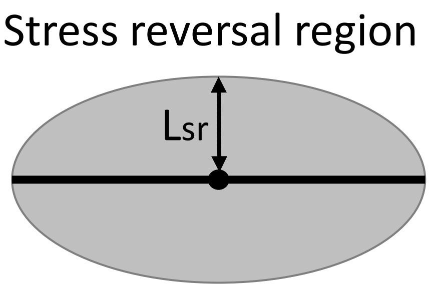




- ➢ Possible re-fracture propagation after five years
- ➢ Attaining of less depleted reservoir region with about 200 bar

NUMERICAL SIMULATION – Impact of Permeability





- Equal maximum dimension for all cases
- Higher permeability effects shifting advanced in time
- Lower permeability effects shifting delayed in time

CONCLUSIONS

- COMSOL Multiphysics enables the coupled simulation of fluid flow and geomechanics
- Based on simplified model the optimum time for re-fracturing treatment can be predicted
- In this model optimum time corresponds to maximum distance to isotropic point as most additional gas is connected to the new fracture
- Quantity of permeability changes the time frame of stress reversal region
- Impact of anisotropy and heterogeneity has been investigated showing:
  - Anisotropic permeability changes maximum dimension and time frame
  - Heterogeneous permeability deforms the elliptical shape of the stress reversal region

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Thank you for your attention!

BACKUP

ENVIRONMENTAL IMPACT OF HYDRAULIC FRACTURING

- Hydraulic fracturing involves advantages and risks
- Under political discussion in Germany
- A neutral body of experts was founded
- For further information visit: www.dialog-erdgasundfrac.de