DEVEX 2025

Increase the Modelling Accuracy of Autonomous Flow Control Technology in Near Wellbore Simulators by Utilizing Scripts

Henrik Ågrav, Team Lead Subsurface

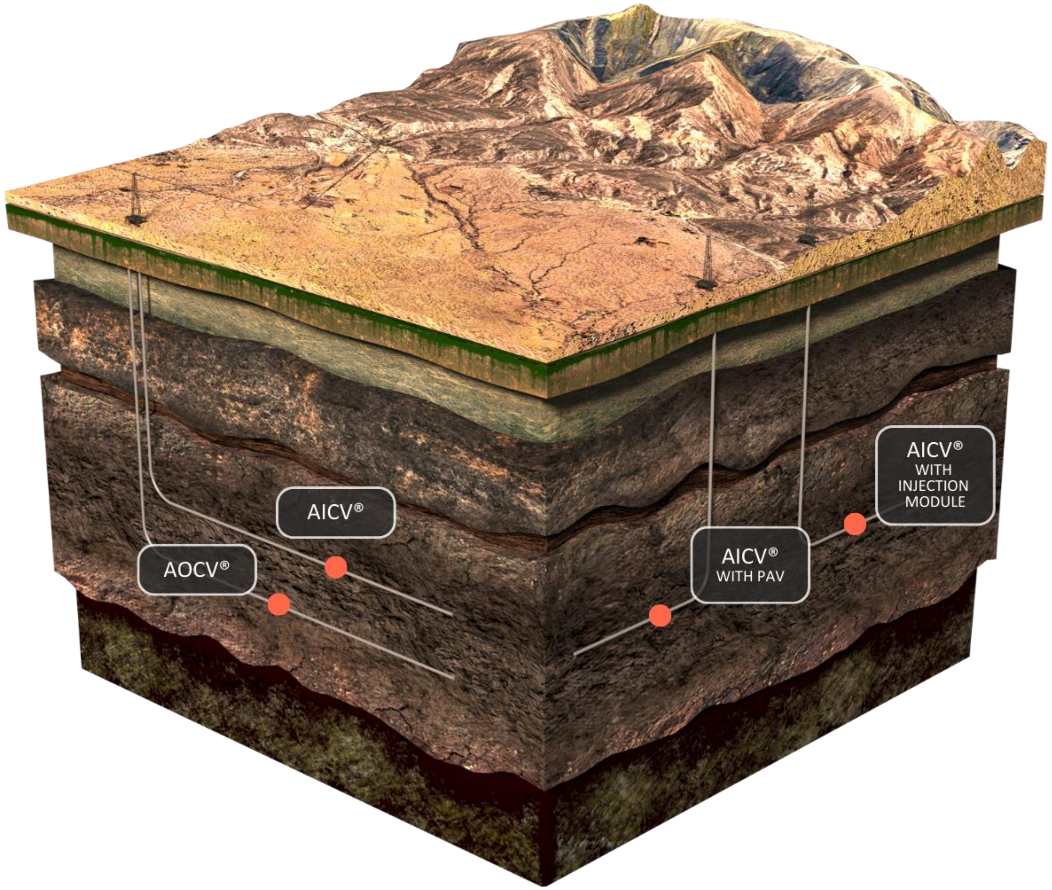
20th May 2025

inflow control

Overview

1. Flow Control Technology
2. Background
3. Benefit of using scripts in modelling
4. AICV Technology
5. AOCV Technology
6. Summary

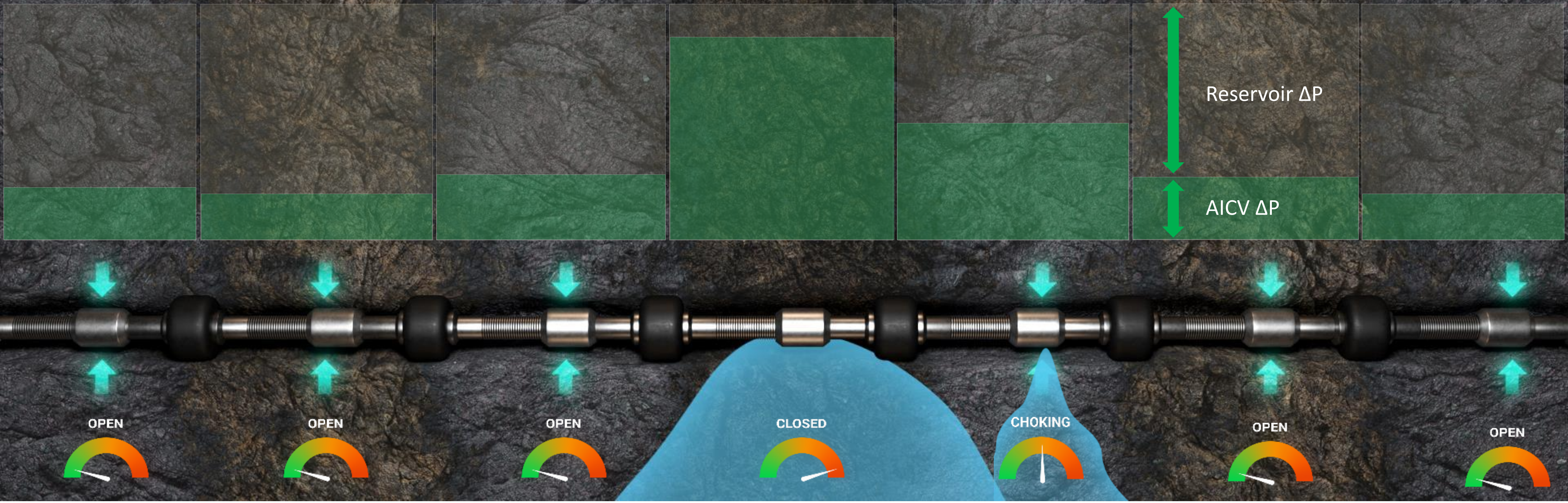
Reservoir Management Solutions



AICV - Autonomous Inflow Control Valve
Autonomously chokes water/gas in the wellbore

AOCV - Autonomous Outflow Control Valve
Allows for even water injection in the reservoir

Managing Oil Production and minimize Gas and/or Water Production



Features:

- Autonomously “Choking / Closing” water zones
- Autonomously “Open” for oil zones
  → By increasing draw down = **> Increased oil production**
- At multiphase flow, AICV *gradually choke,* promoting better oil production

Results:

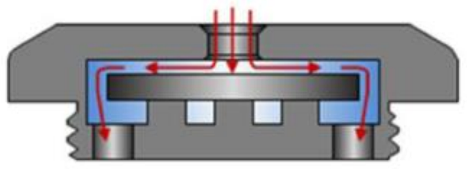
1. Increased oil production and recovery
2. Reduce unwanted production of gas and water
3. Reduce CO_2 emissions & energy requirements

inflow control

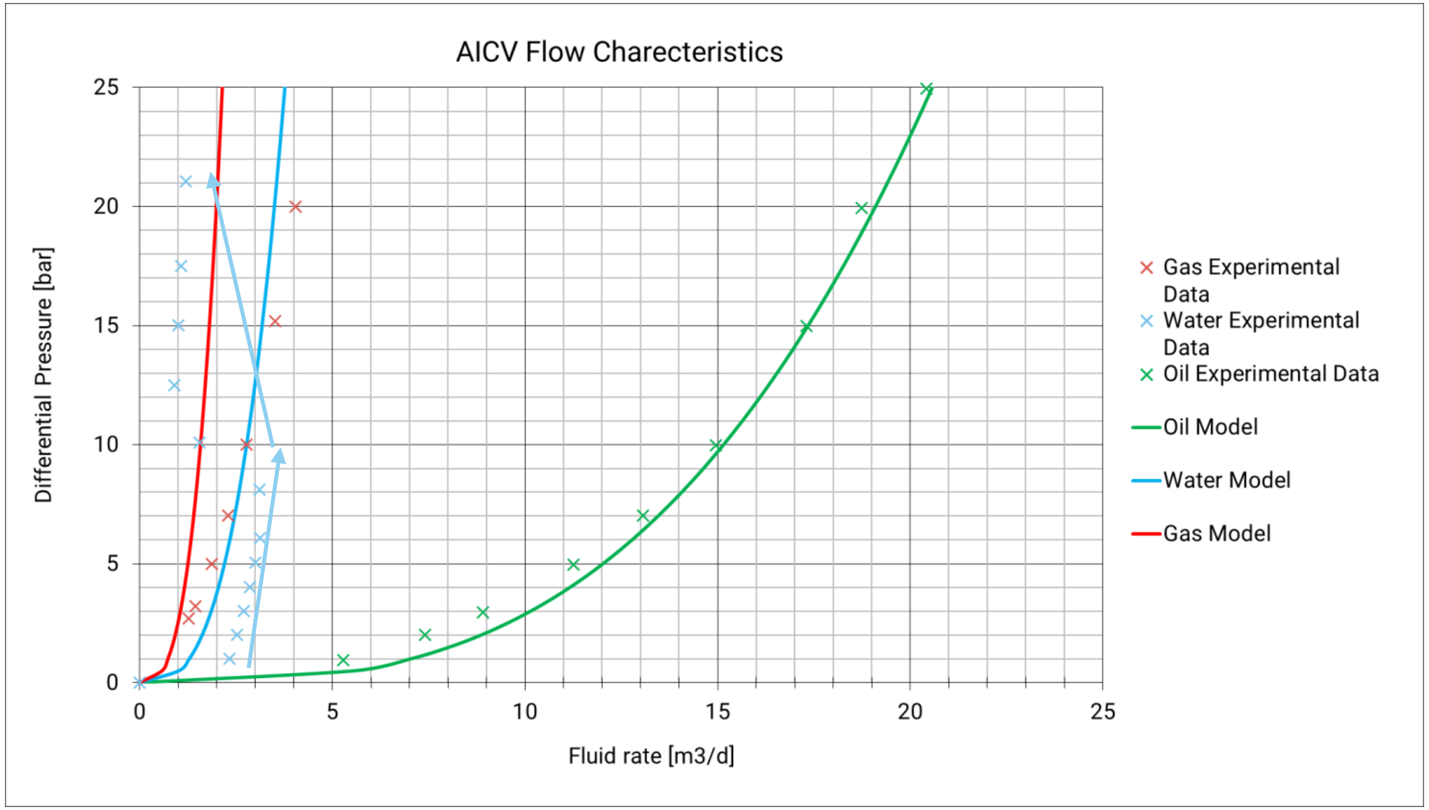
Background

- RCP-Equation (Mathiesen et al. 2006)

$$\Delta P = \left(\frac{\rho_{mix}^2}{\rho_{cal}}\right)^z \left(\frac{\mu_{cal}}{\mu_{mix}}\right)^y .a_{AICD}.\, q^x$$



- Originally created for RCP-AICD Design, which does not fully close
- Does not capture full scope of AICV choking capabilities
- Solution to this issues was to use a script (C#, python)



More open for water at low DP for bean-up purposes, before fully closing after 10 bars

inflow control

Benefit of using scripts in modelling

- Modify equation to add all parameters

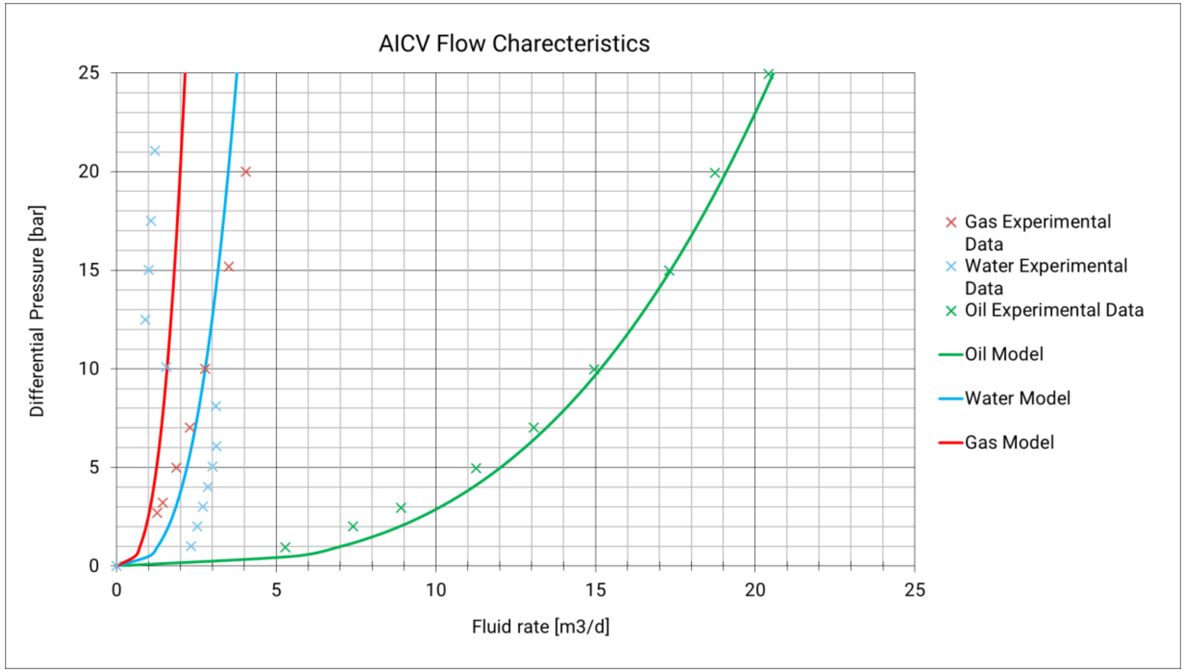
$$\Delta P = \left(\frac{\rho_{mix}^2}{\rho_{cal}}\right)^{z} \left(\frac{\mu_{cal}}{\mu_{mix}}\right)^{y} .a_{AICD}.\, q^{x}$$

- Solve for non continuous behavior (multiple y values for the same x value)
- Add simple logic (if, else, etc..) to optimize model behavior to match test data
- Add restraints to prevent or decrease numerical errors
- Can add multiple set of coefficients to solve for various viscosity ranges
- Fairly simple to make and modify

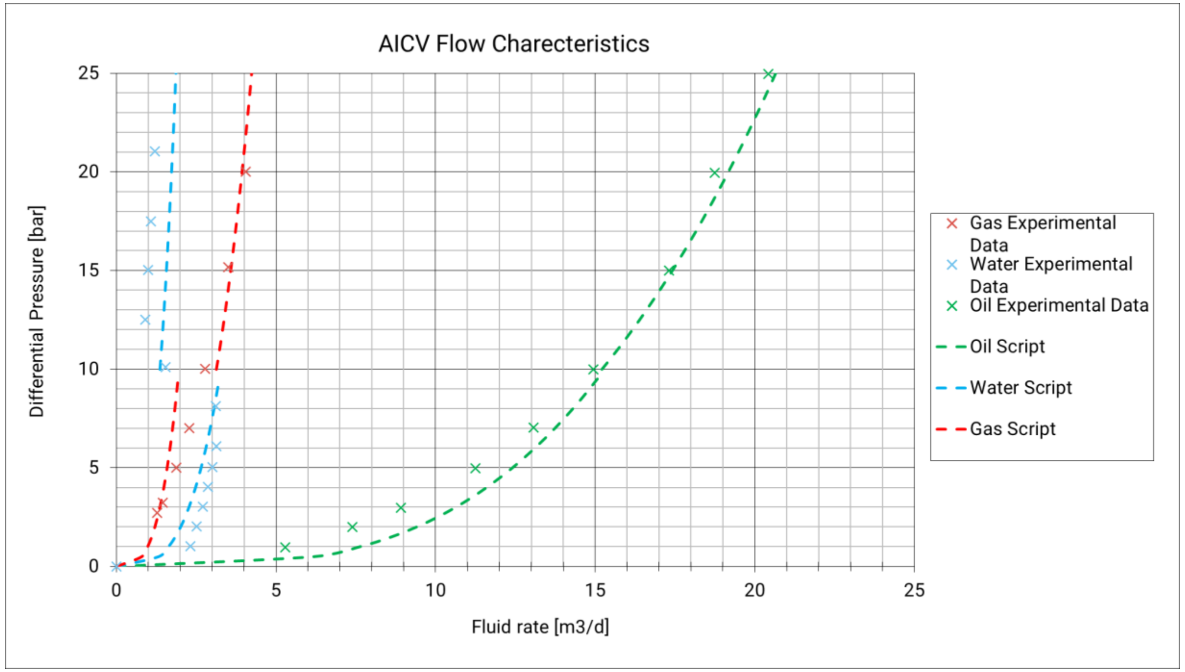
AICV with script

- Using multiple “DP Zones” in a script helps improve modeling accuracy
- Captures the 2 stages of AICV behavior (choking, then closing)
- Scripts are simple to set up and modify if needed

No script



AICV® script

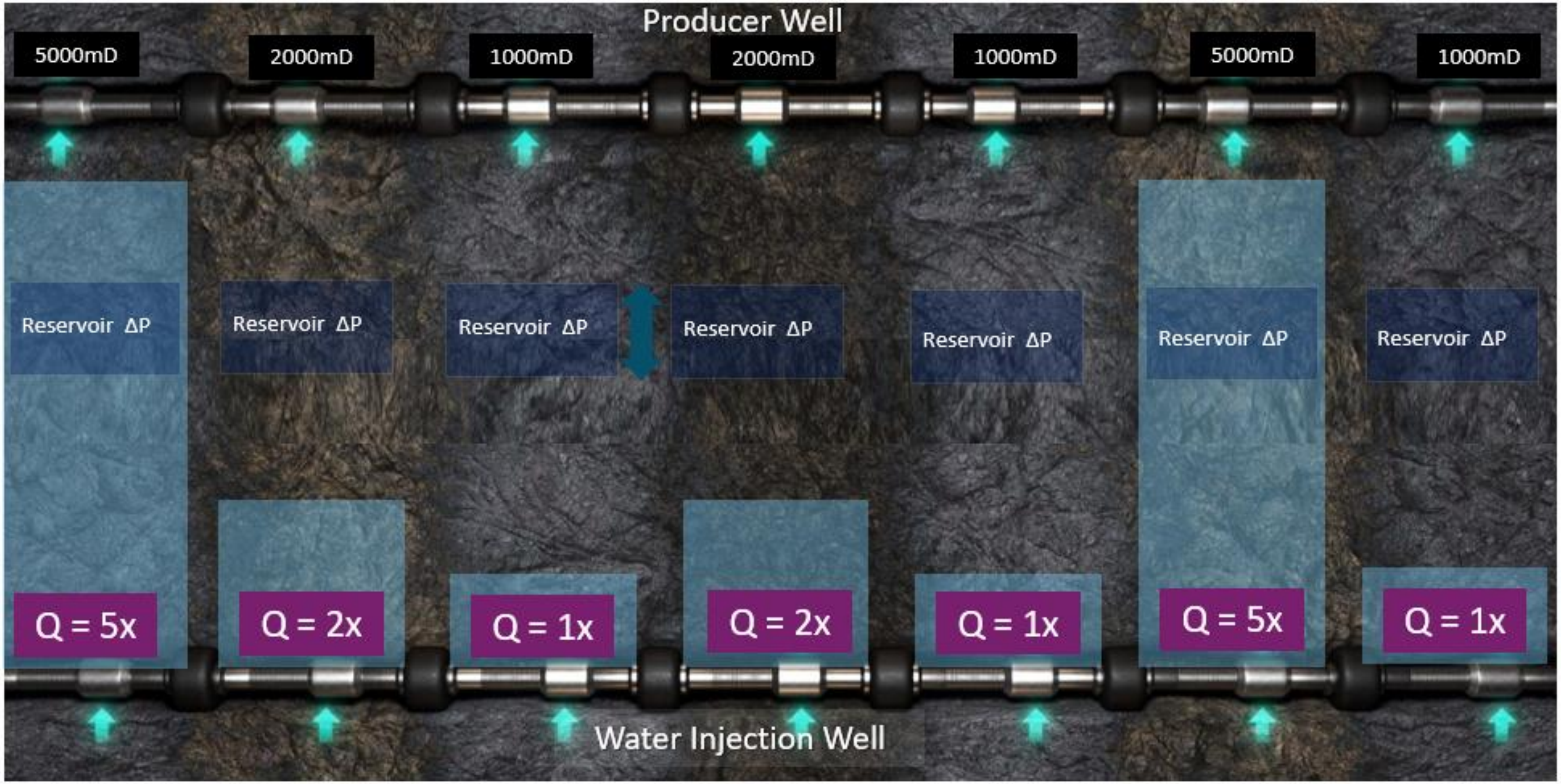


inflow control

Challenge for Horizontal Injection Wells

Darcy's law: $Q = \frac{KA}{\mu L}(\Delta P)$

Naturally, most of the flow goes where there is least resistance

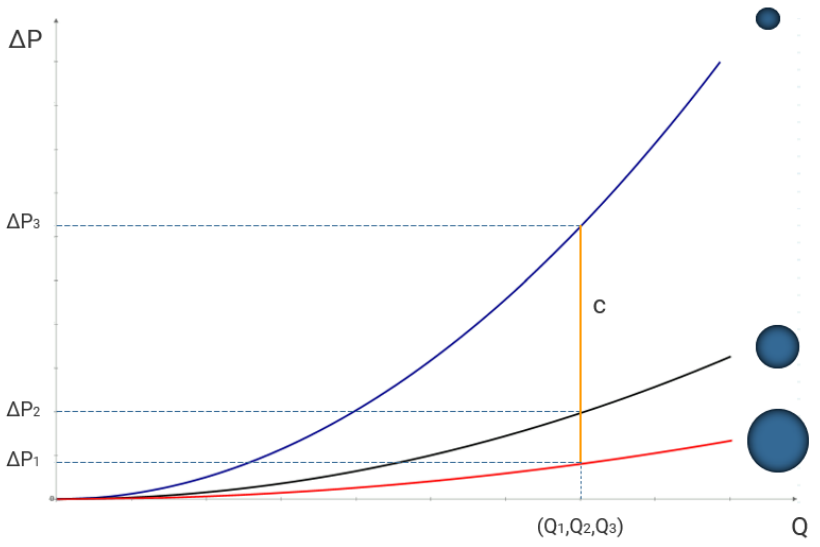


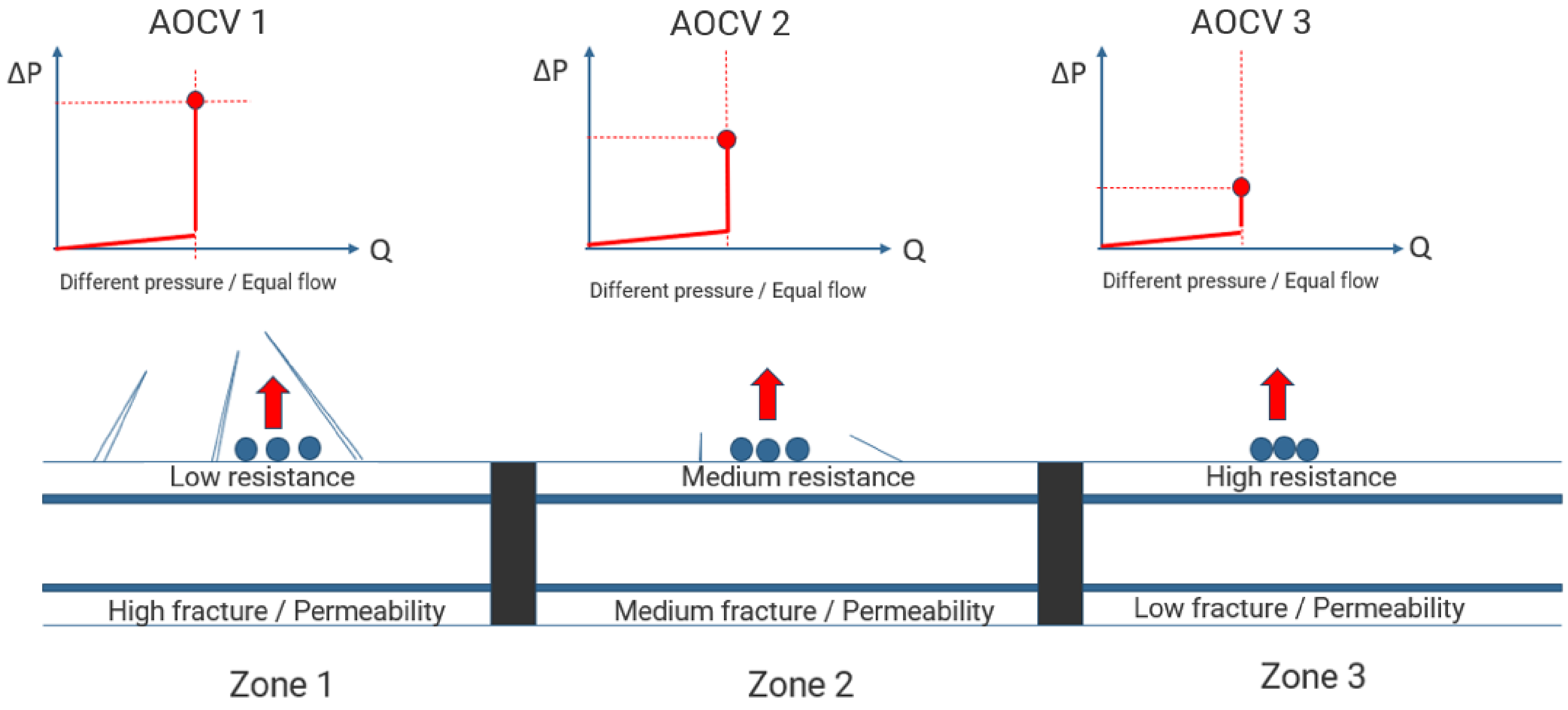
inflow control

Poor sweep efficiency & inefficient water injection

Challenge for Horizontal Injection Wells

- Want water to flow everywhere
- ICD sizes, smaller flow area, less flow
- If constant flow wanted, need to have a flow area based on ΔP over valve
- Solution: Variable opening Autonomous Outflow Control Valve (AOCV)
- Creating more resistance where needed with the AOCV to balance outflow

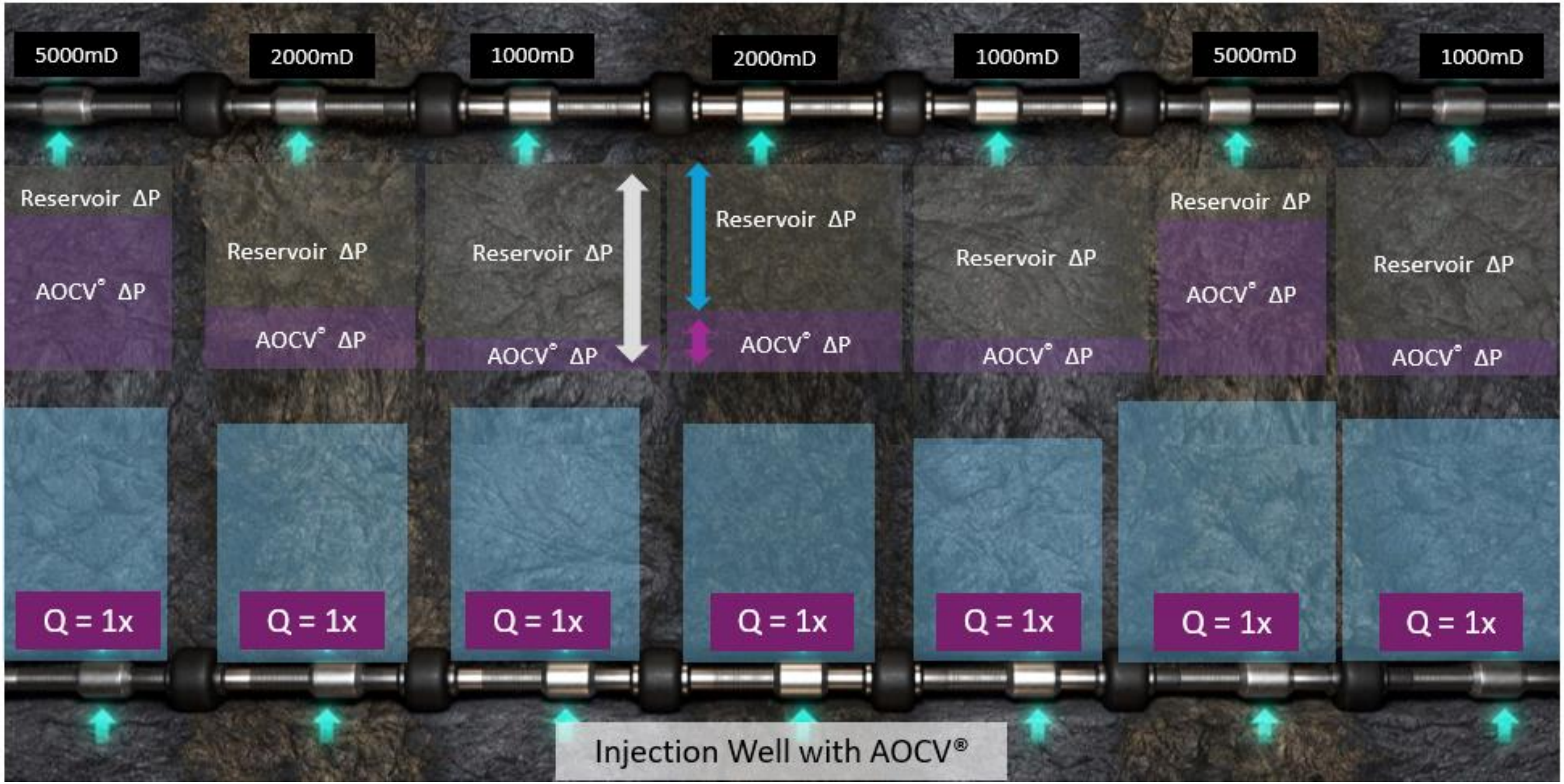




inflow control

AOCV in horizontal injector wells

Darcy's law: $Q = \frac{KA}{\mu L}(\Delta P)$



Uniform sweep efficiency

inflow control

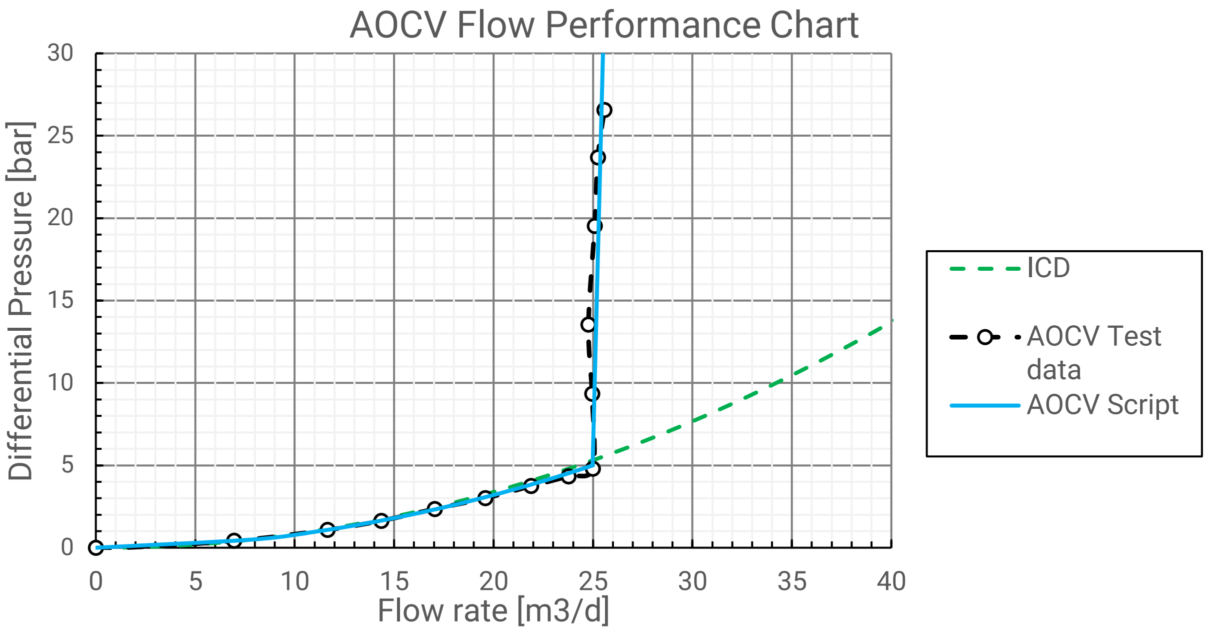
AOCV Script

AOCV includes 2 operational stages:

1. Below 5 bar, ICD behavior
2. Between 5 -30 bar, constant flow rate

Difficult to model with conventional built-in completion settings in modelling software

Scripts enables flexible and practical solution that matches with real test data

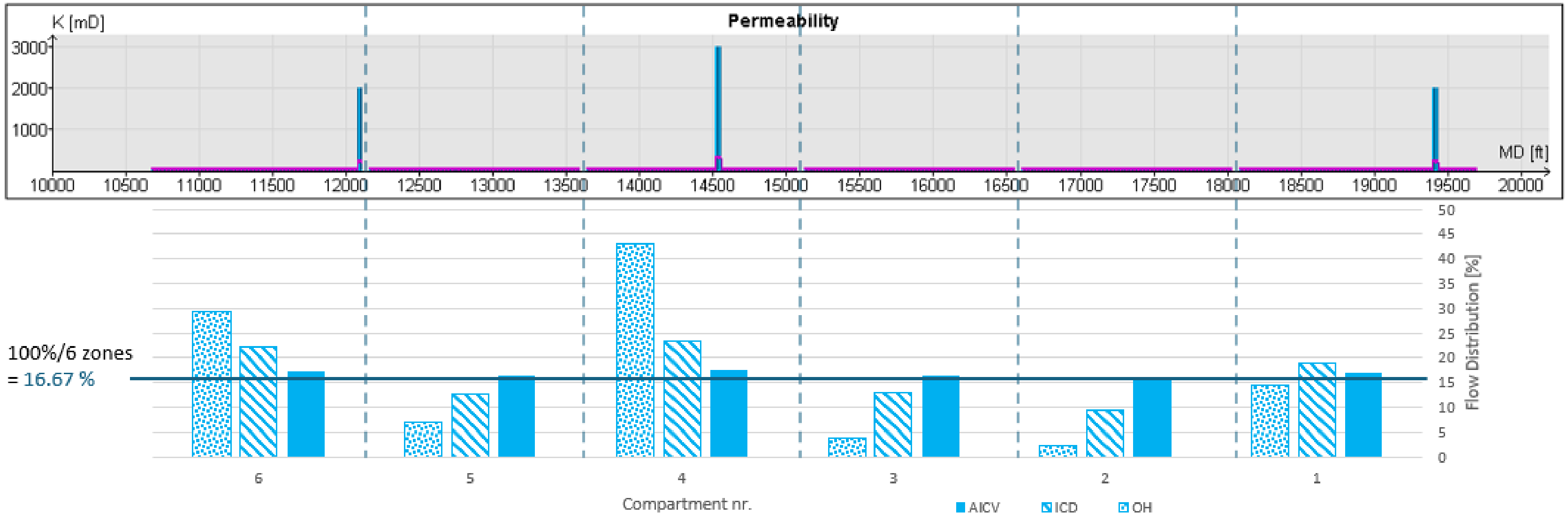


Modelling example – Static modelling:

Fractured carbonate reservoir

10k STB/d injection rate

AOCV injecting an even amount of water in all zones, while ICD and OH are prone to “thief zones” in the form of fractures



inflow control

Summary

- Modelling complex technology behavior is difficult with only using a single equation
- Adding logic may help manage the problem
- Using AICV scripts improves the accuracy by adding conditional statements
- For the AOCV technology, simple scripts can be used to describe the two-stage operating window to use for modelling

- In general: scripts provide a flexible solution for modelling complex physics in simulation software. Also simple to modify

Thank you!

Q&A

Henrik Ågrav, Team Lead Subsurface

20th May 2025