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# Improved Oil & Gas Recovery by Polymer Technology: EOR, Water Shutoff and Sand Control

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Society of Petroleum Engineers  
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# Outline

## 1. EOR Challenges

## 2. Polymer Flooding

General aspects

Field case in heavy oil reservoir

## 3. Water Shut-Off

Fundamentals of WSO by RPMs

WSO gas well field case

## 4. Sand Control

Principle of sand control by polymers

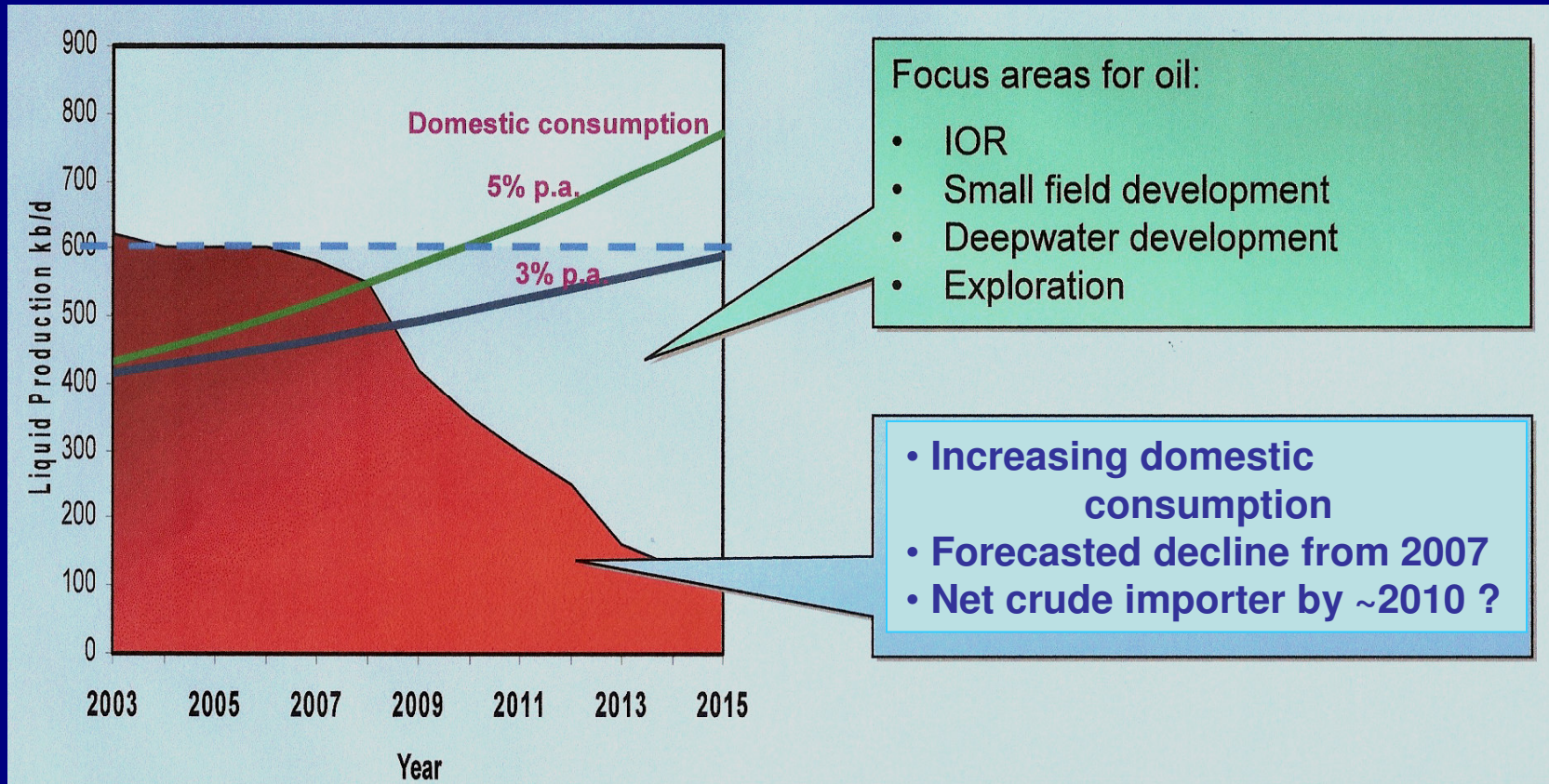
Sand control in gas storage wells

## 5. Conclusions

# EOR Challenges

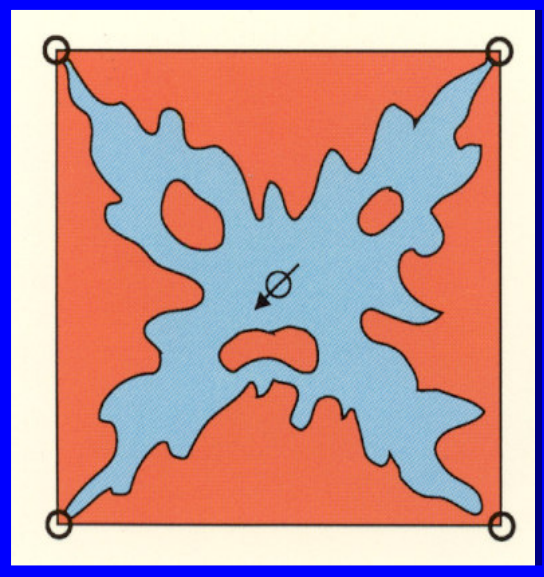
- **Peak oil occurring soon, oil slow decline expected**
- **EOR enables increase in Recovery Factor**
- **Teams mobilized in Major Oil companies to implement EOR**
- **Chemical EOR attractive, major focus on polymers**
- **Low capital cost, low risk, waterflood improvement**

# Malaysia Scenario

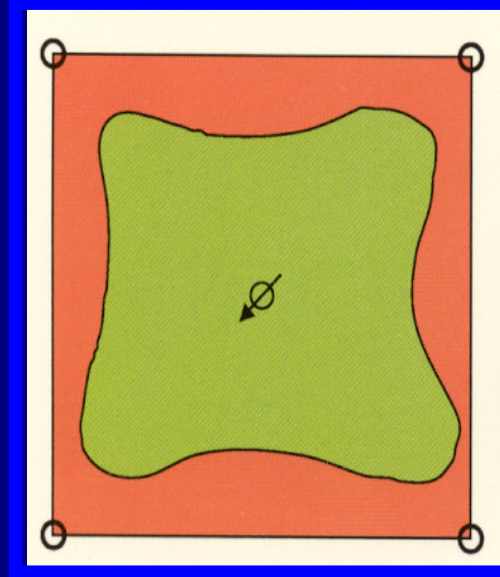


# EOR by Polymers

**Polymer Flood improves Mobility Control, thus reservoir sweep efficiency**



**Water flooding**



**Polymer flooding**

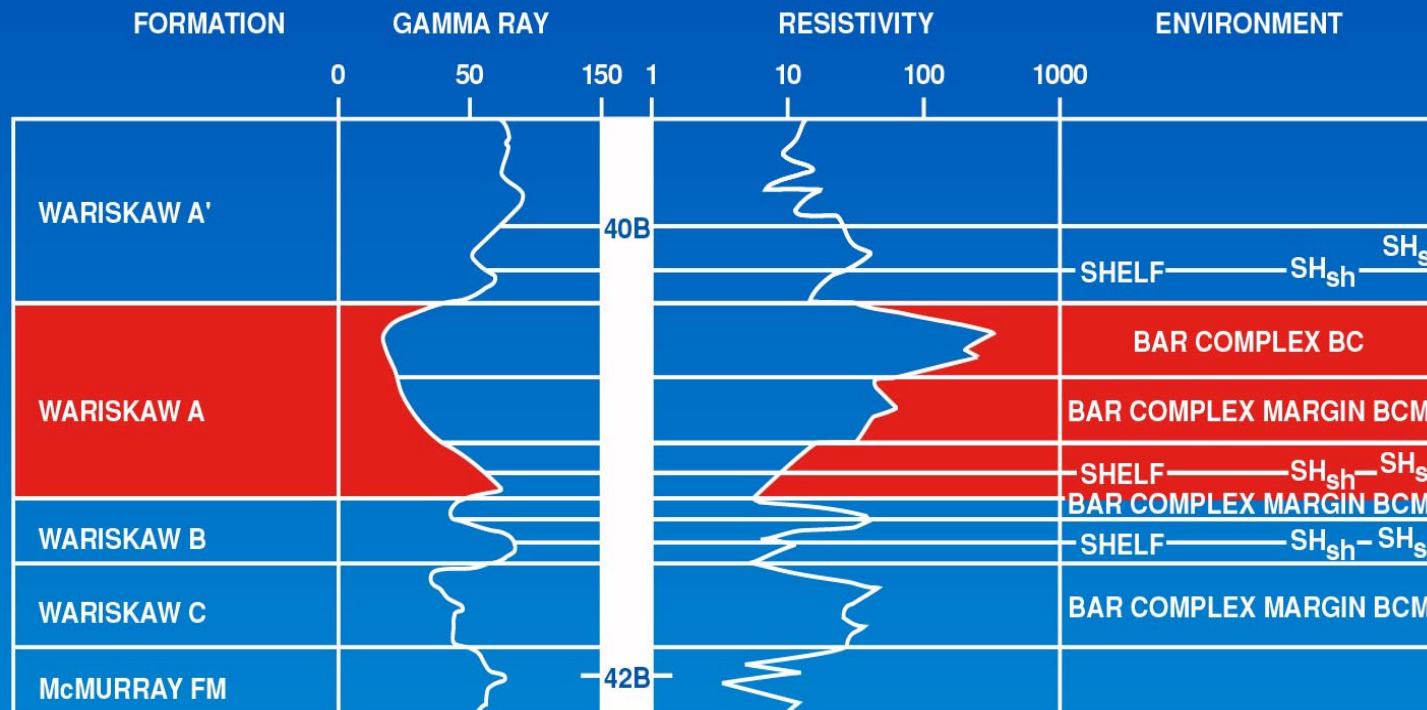
**Polymer Flood:  
Heavy-Oil Application (Canada)**

# Pelican Lake heavy oil field

- **High-permeability sand reservoir**
- **Thin continuous pay layer (4 m thick)**
- **Heavy oil – 14° API – 2000 cP**
- **Shallow, low temperature, fresh water**
- **Horizontal well primary production**
- **Low recovery factor (around 5%)**
- **RF expected to jump to 25% with polymer flood**

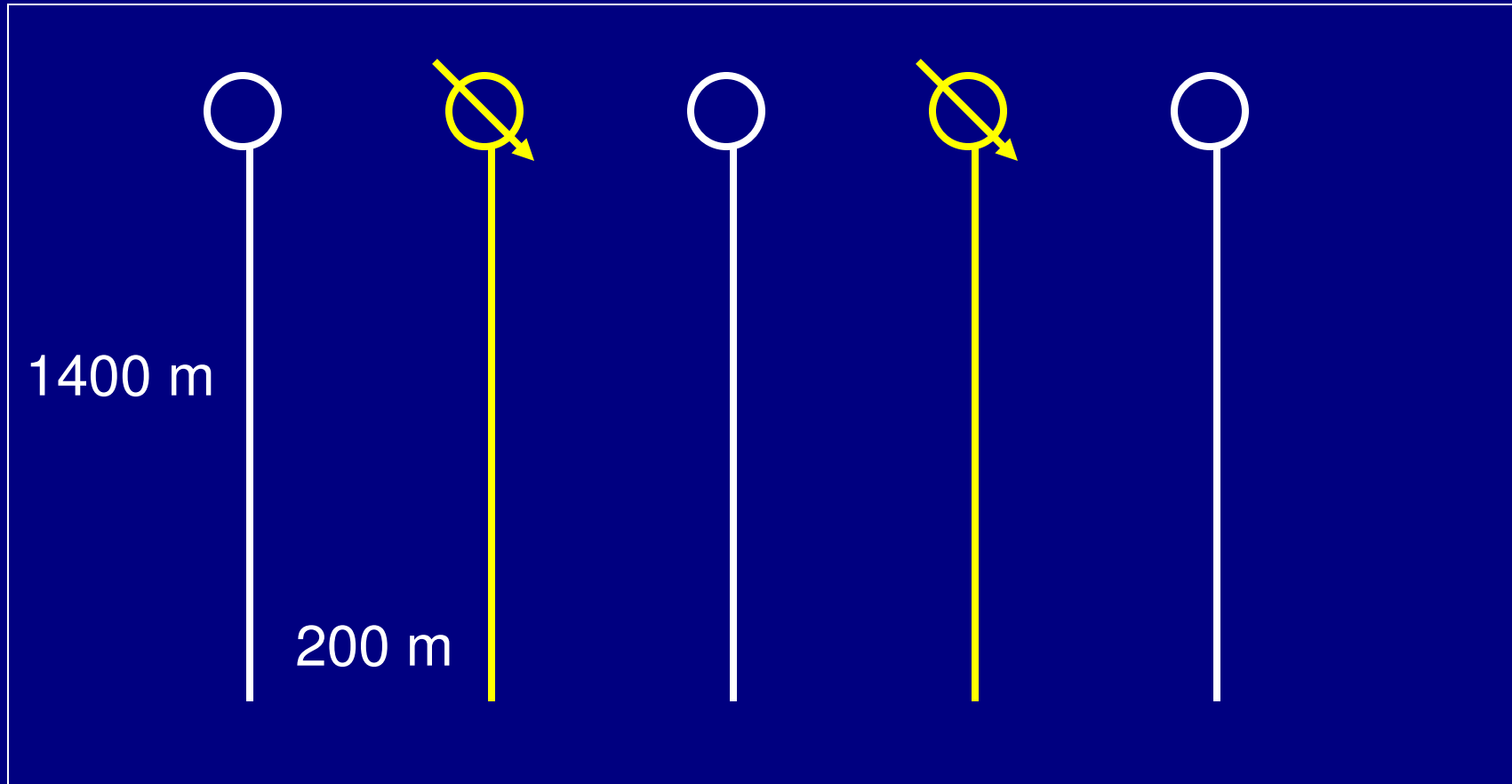


## Composite log-Wabiskaw section



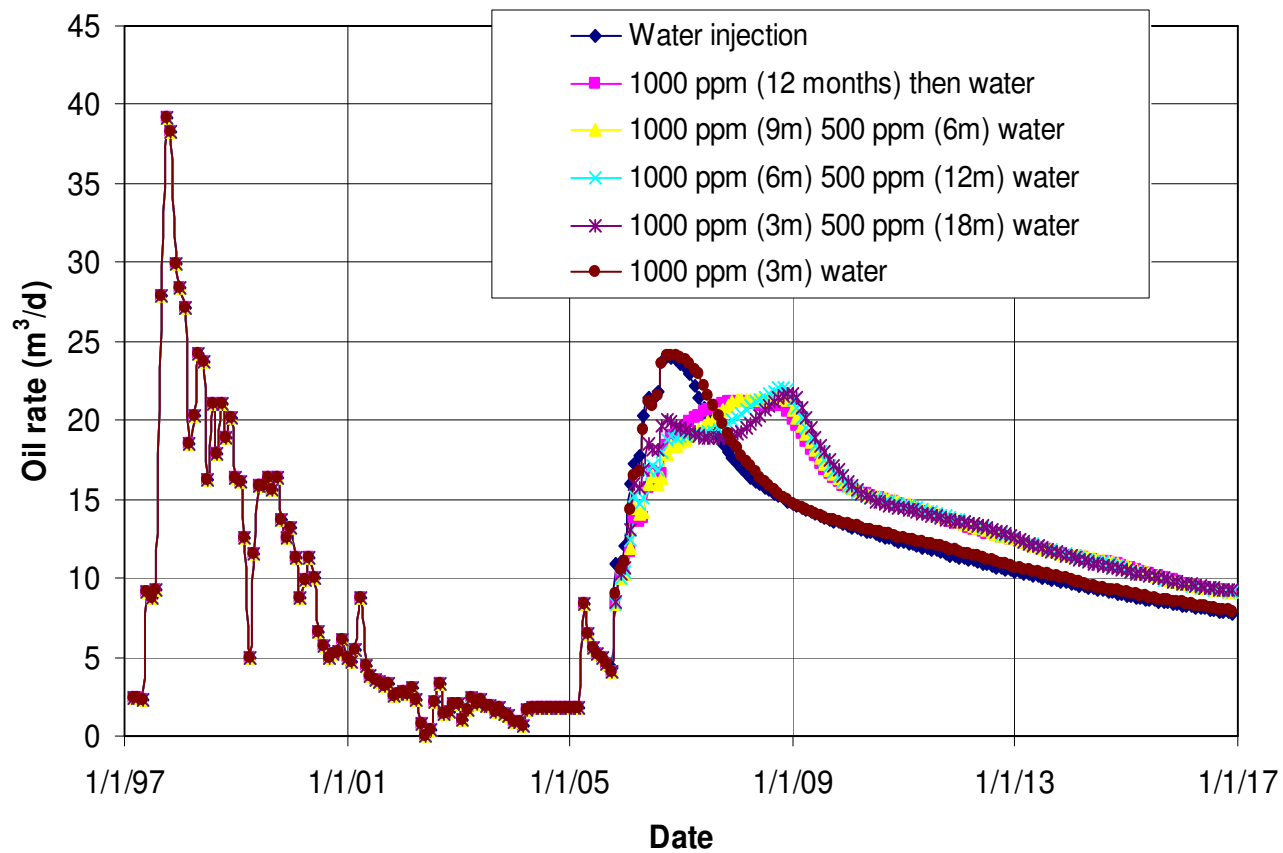
Typical stratigraphy in area around pilot site. Section is repeated three times except that no bar complex is present in the Wabiskaw B and C units.

# Pelican Lake Polymer Flood Pilot



# Simulation of Polymer Injection Scenarios

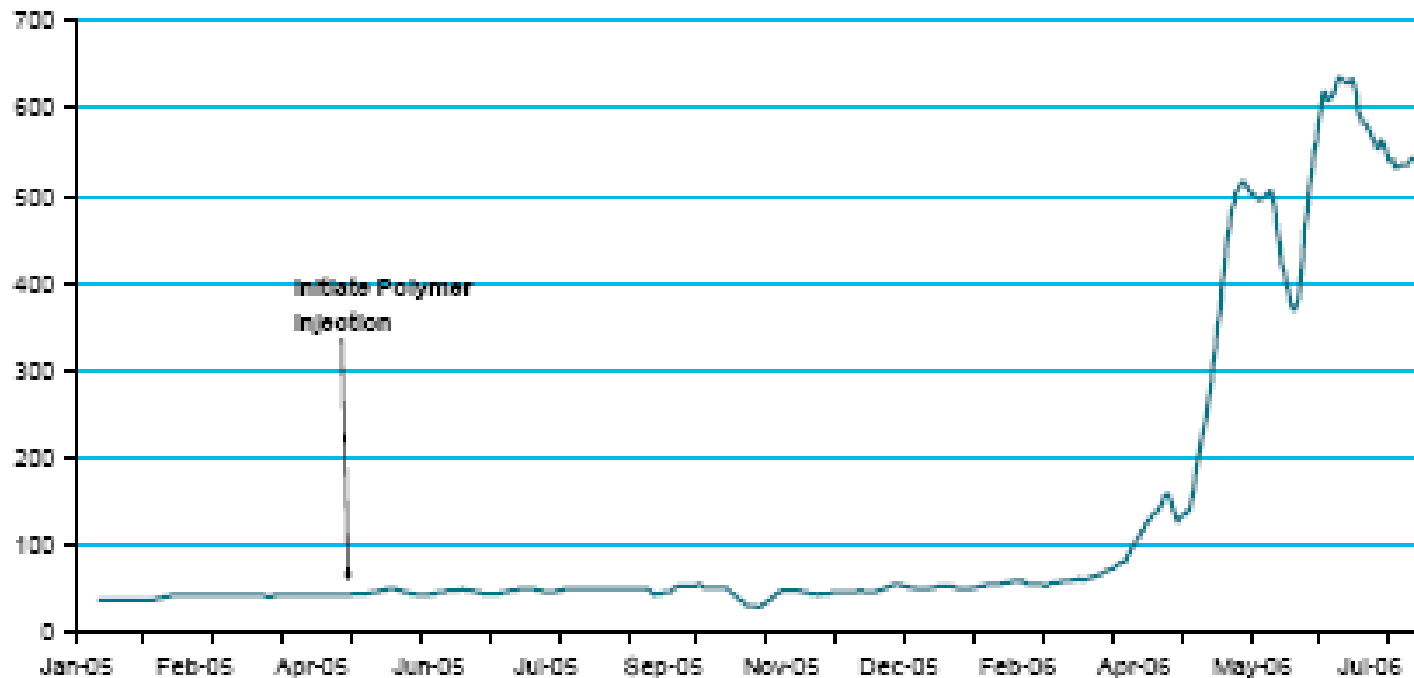
**Oil rate in Central Producer 00-15-PRO**  
**Max Injection & Production Rates 150 m<sup>3</sup>/d**



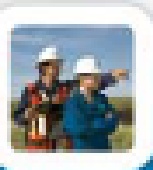
# Pelican Lake Polymer Pilot Response



Oil Production (bbl/d)  
Wells 14-34, 15-34, 16-34



CNQ



Implementing New Opportunities

## Main outcomes of Polymer Flood pilot

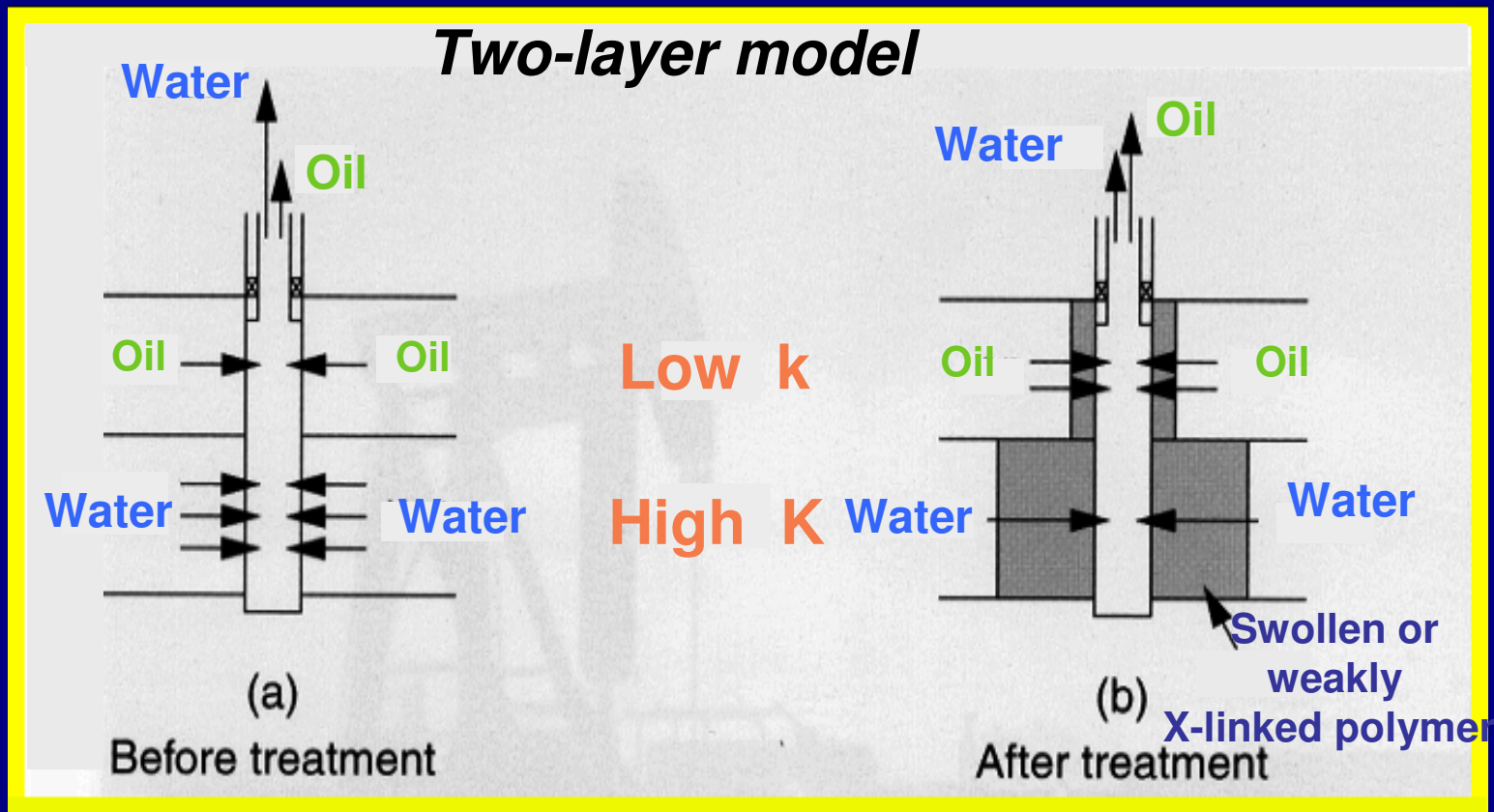
- Polymer Flood has potential in heavy-oil reservoir
- In combination with Horizontal Wells
- Integrated Lab & Simulation studies help designing pilot
- Polymer injectivity is an essential issue
- First pilot results very positive, field extension implemented by operator (270 injection wells in 2009)

# Water Shutoff

## Water Shutoff by Polymer/Gels

- Two strategies: (1) Sealing gels and (2) RPM
- Sealing gels block a water producing interval
- Sealing gels compete with cements or packers
- Relative Permeability Modifiers are weak polymer/gels
- Usually “bullhead” injected into the whole open interval = cost effective
- Maintain oil/gas permeability while reducing strongly water permeability

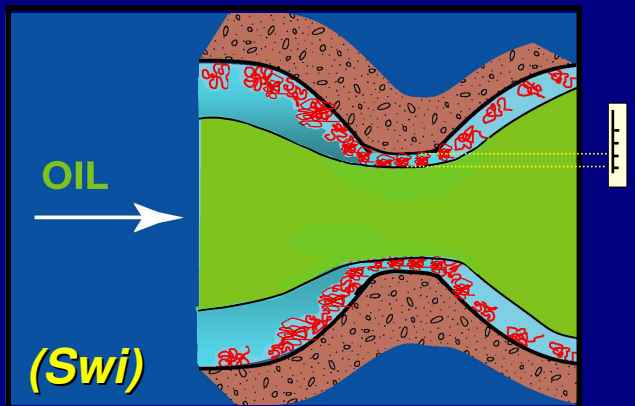
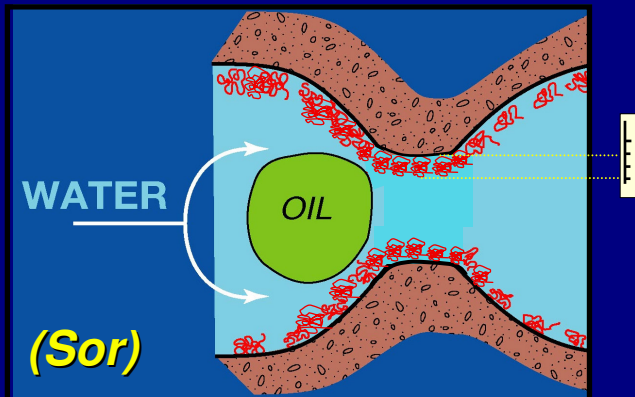
# Principle of WSO by RPM Polymers



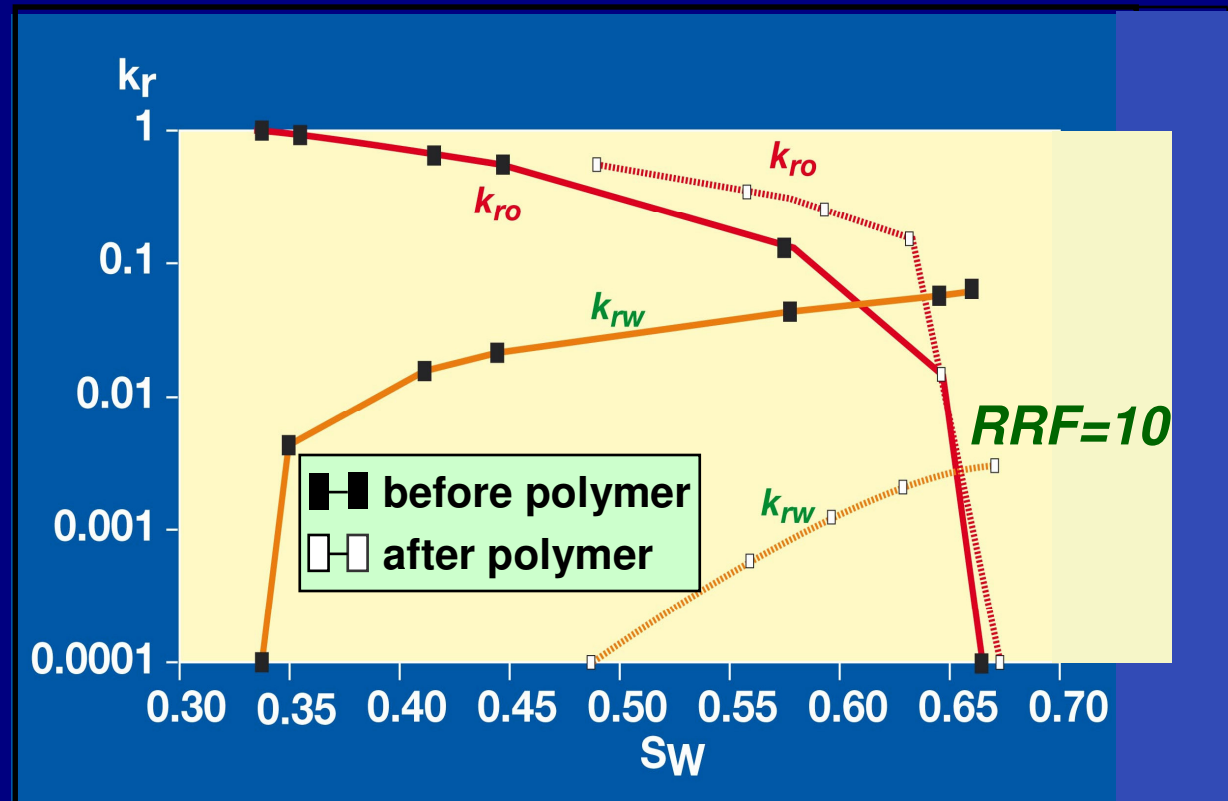


# Principle of RPM treatments

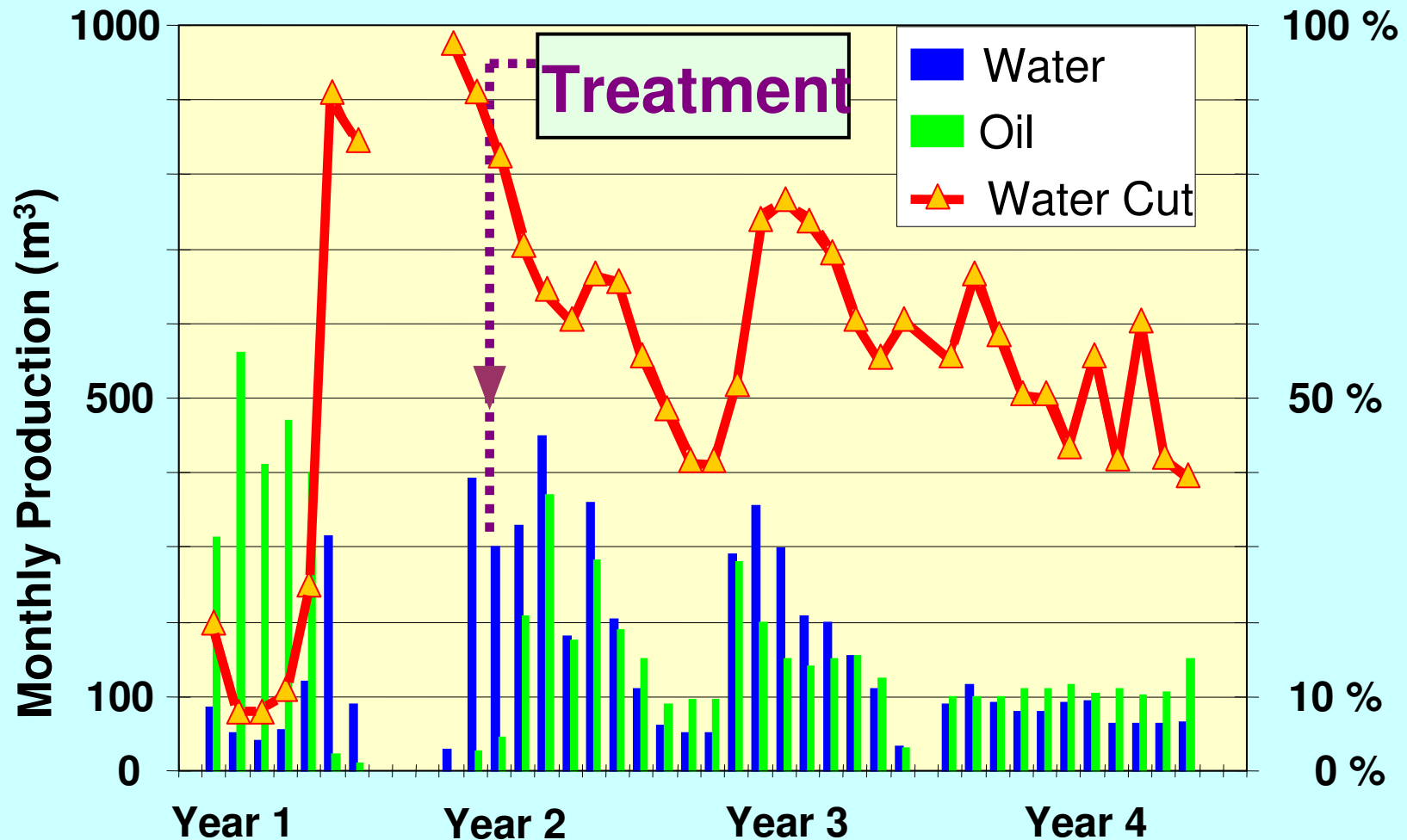
## Modification of Relative Permeability by Polymer Adsorption



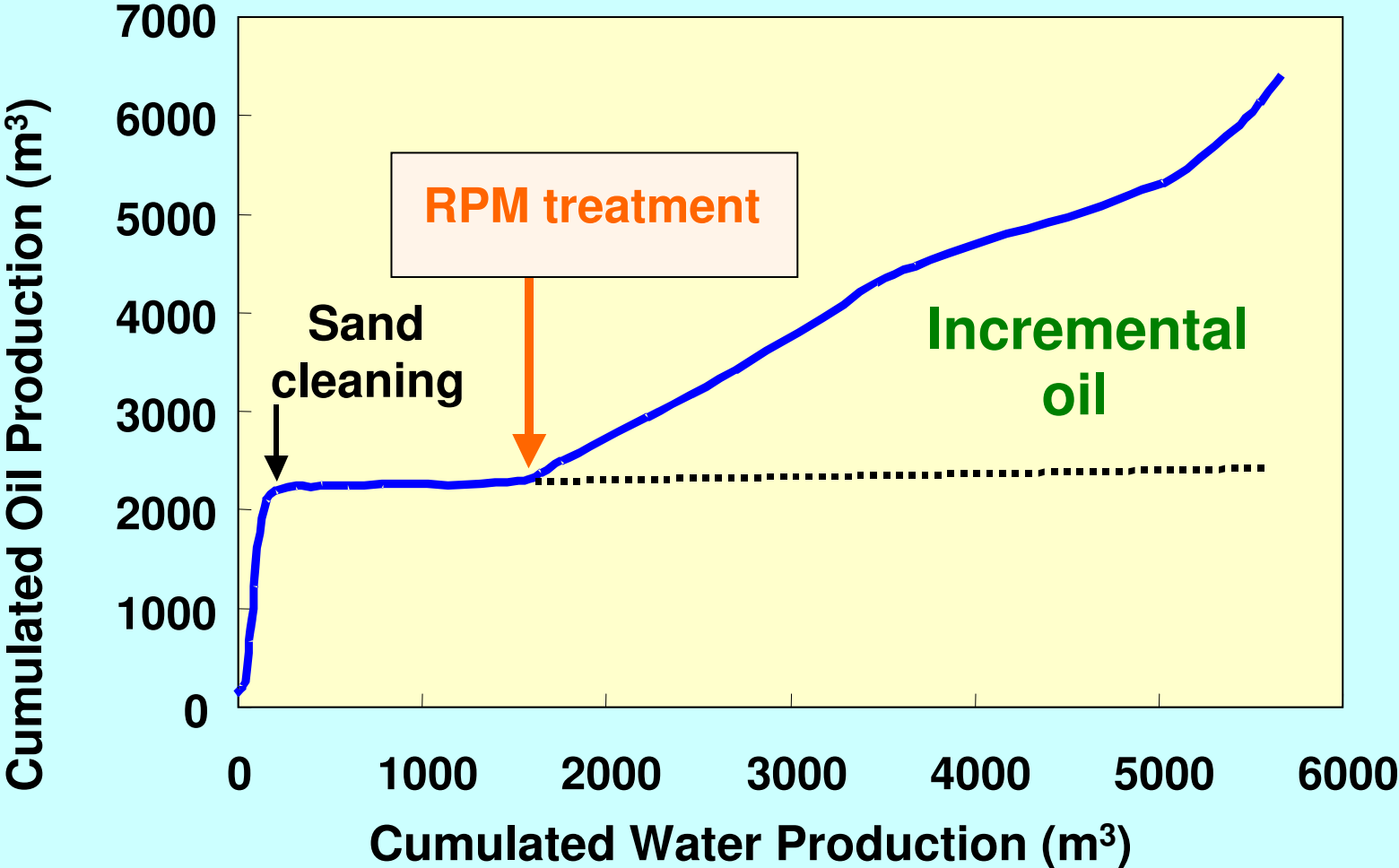
Adsorbed polymer or microgels



# Example of successful WSO treatment Pelican Lake Horizontal Well 11-15A (Canada)



# Successful WSO treatment in horizontal well (Canada)



# New Microgel Technology

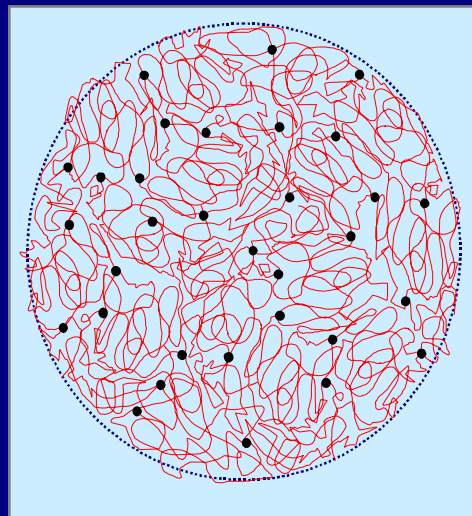
SMG are calibrated microgels larger and more stable than conventional polymers

$d_H \approx 0.3 \mu\text{m}$

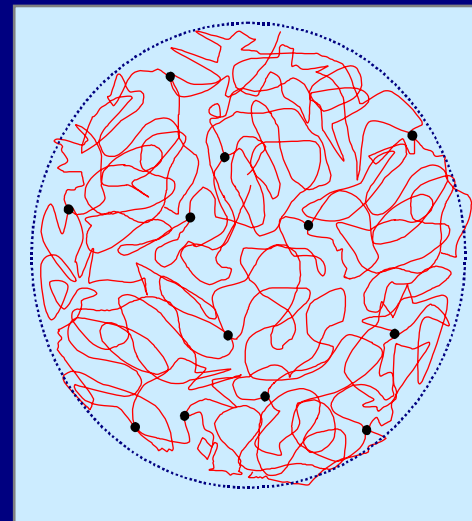


Linear polymer  
Linear chain

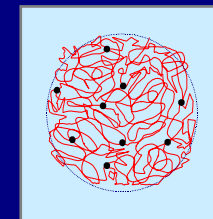
$d_H \approx 2.0 \mu\text{m}$



Microgel A



Microgel B



Small microgel

## Several Microgel products proposed today

- “Brightwater” (Popping microgel)
- “Colloidal Dispersion Gels” (CDG)
- “SMG” (Small calibrated microgels)
- “PPG” (Preformed Particle Gels to plug thief zones)
- More used for Conformance Injection well treatments

# **Example of integrated study:**

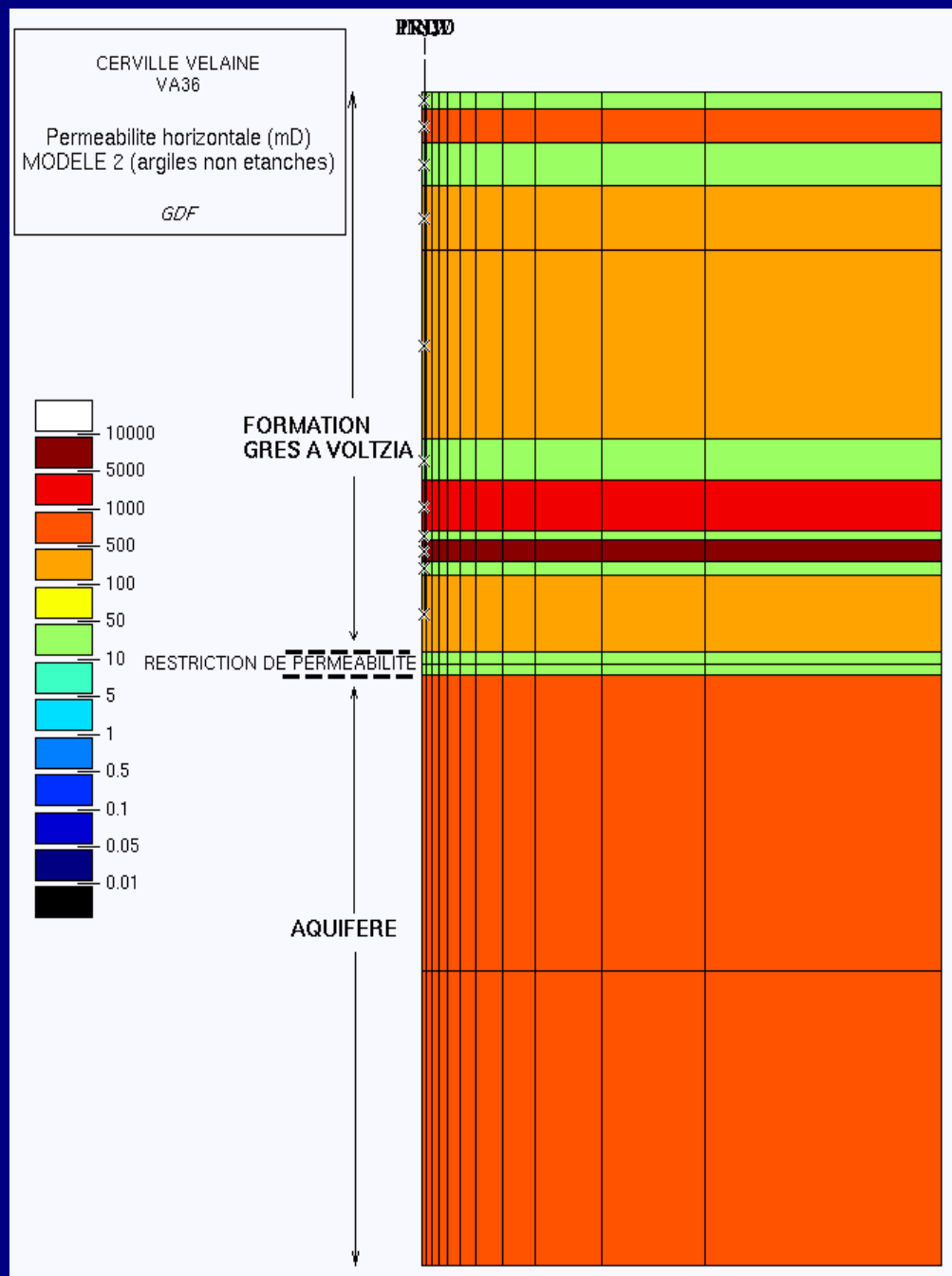
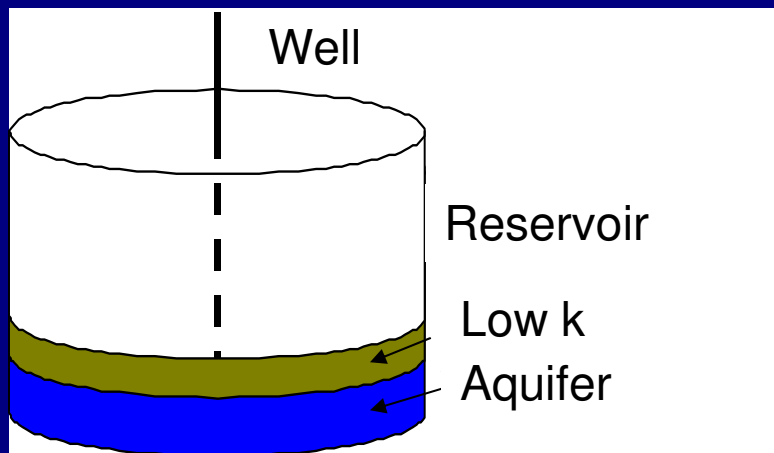
**Water Shutoff in a**

**Gas storage well**

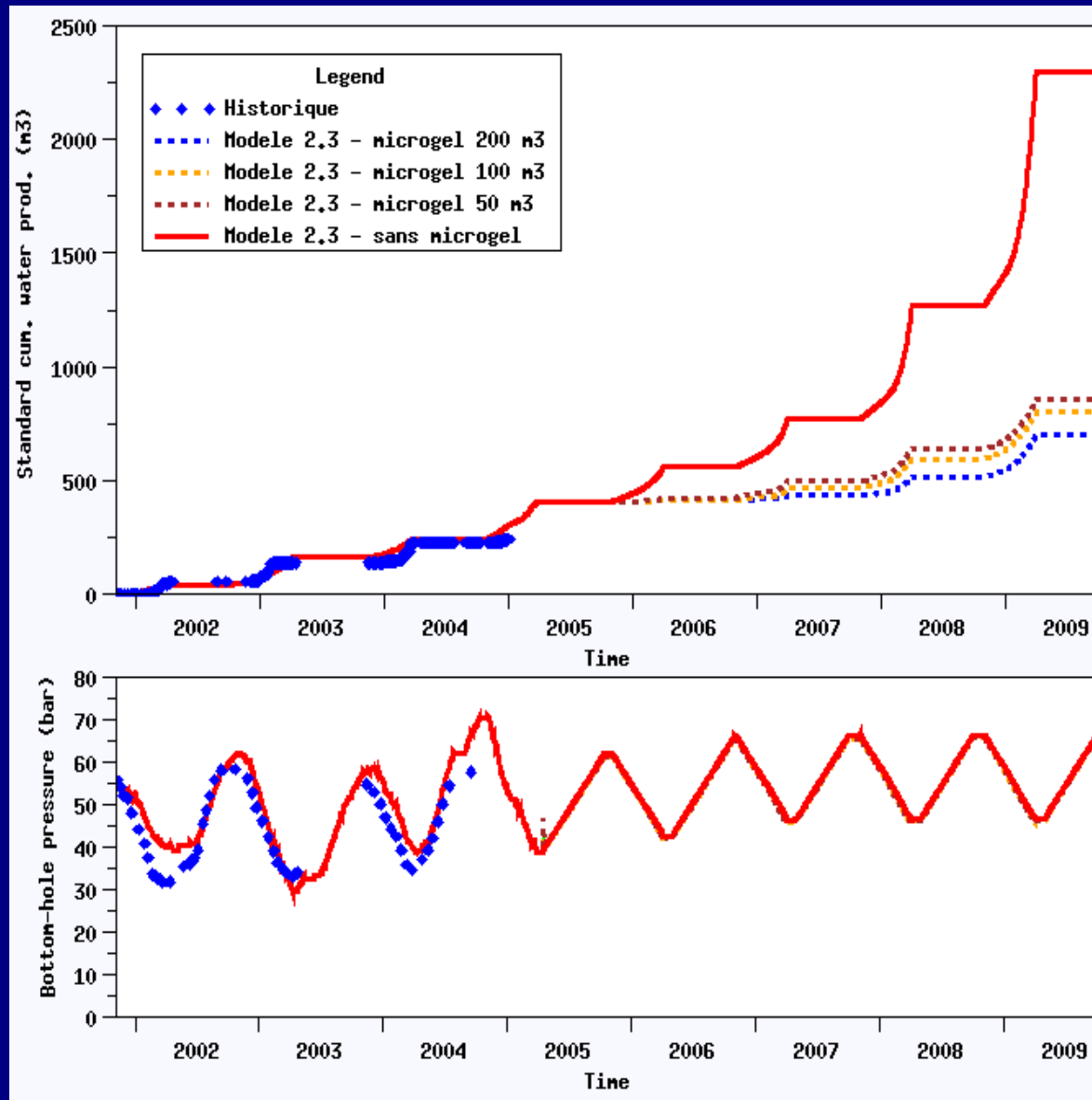
**Cerville (GDF)**

***(SPE 106042)***

# Model construction



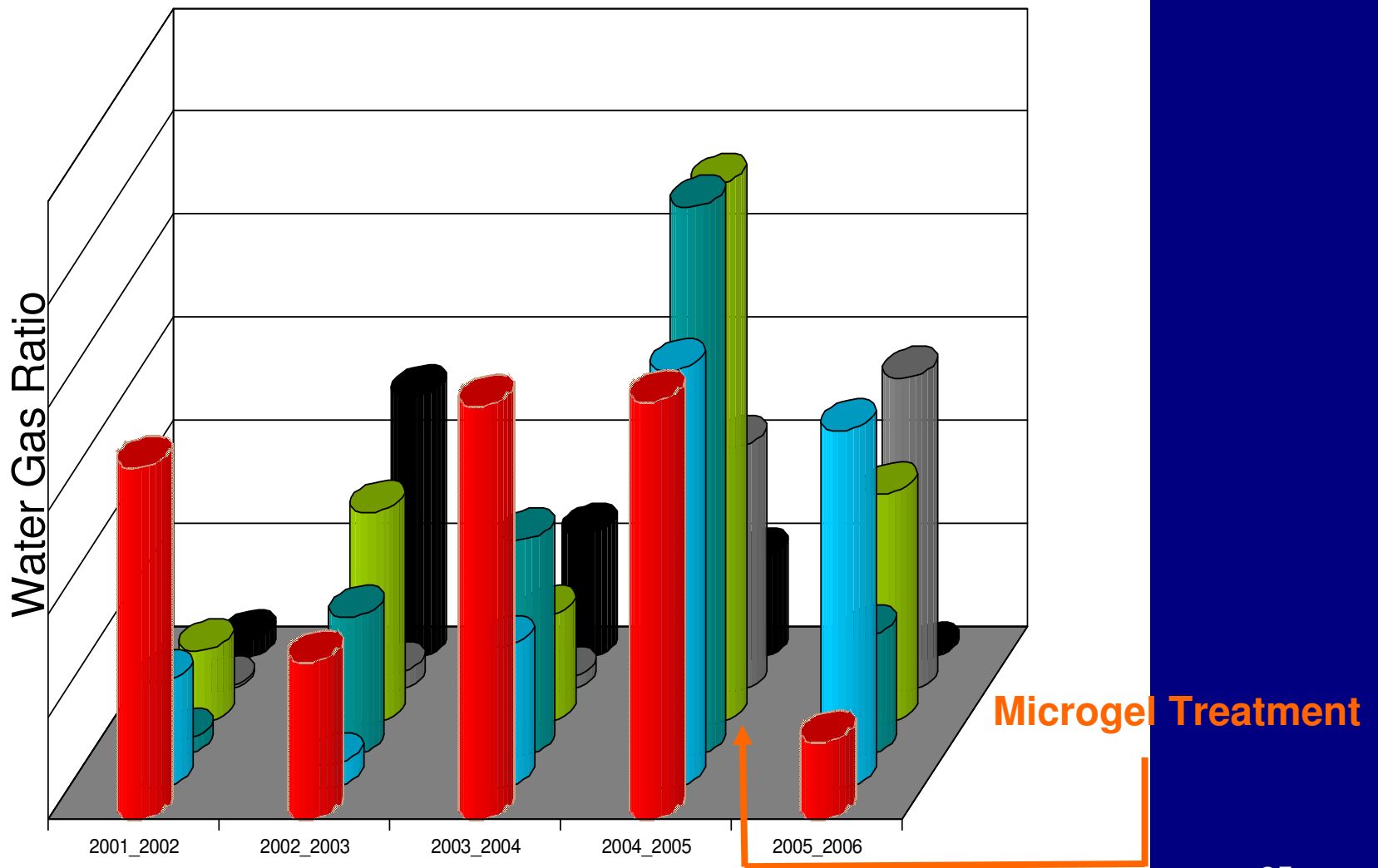
# Simulation forecasts





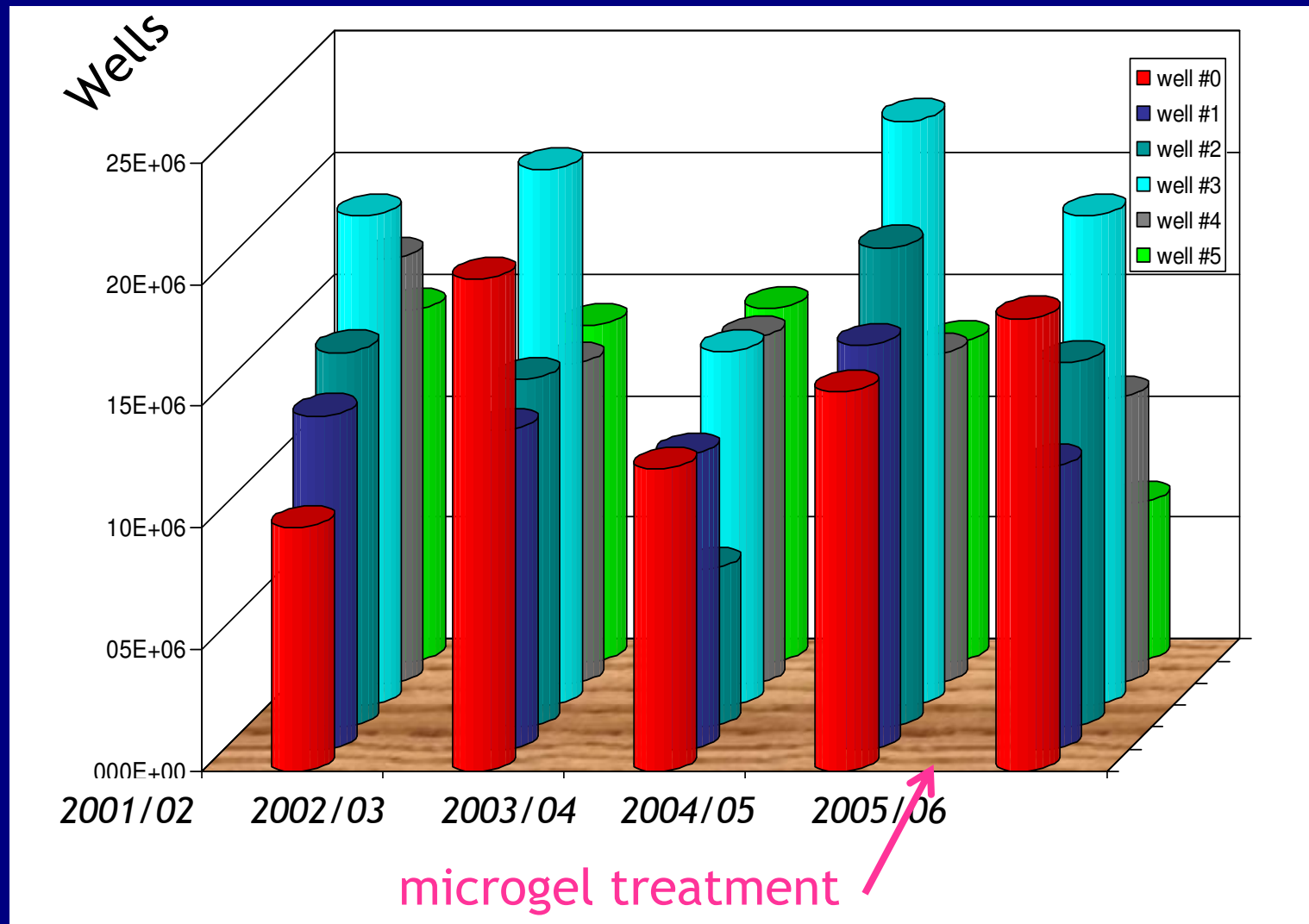
# Effect of Microgel WSO treatment on gas well

## Drop in water production



# Effect of Microgel WSO treatment on gas well

## Increase in Gas Production rate

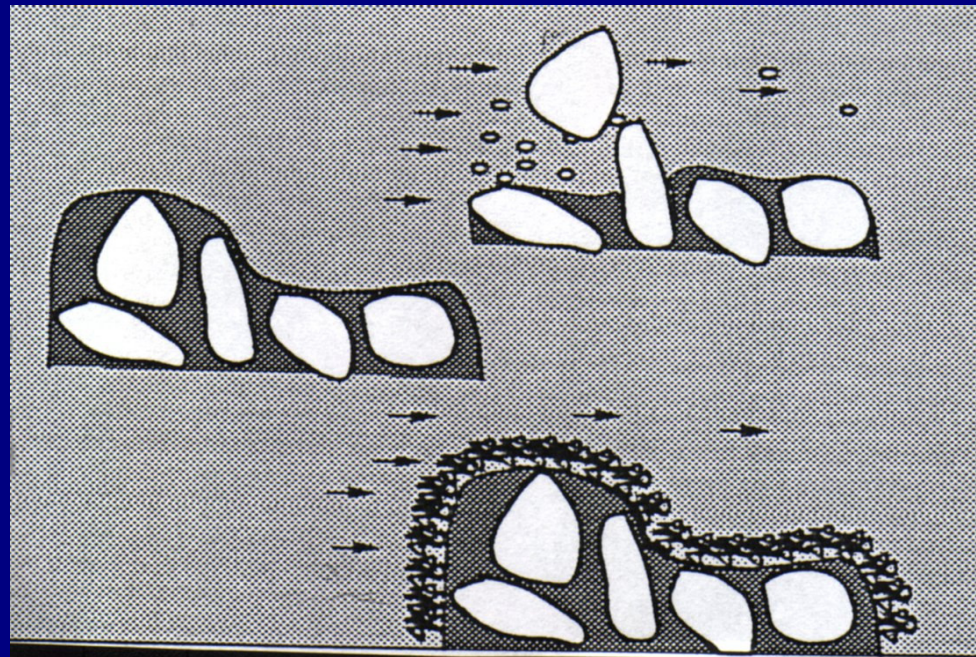


# Sand Control by Polymers



## Principle of action:

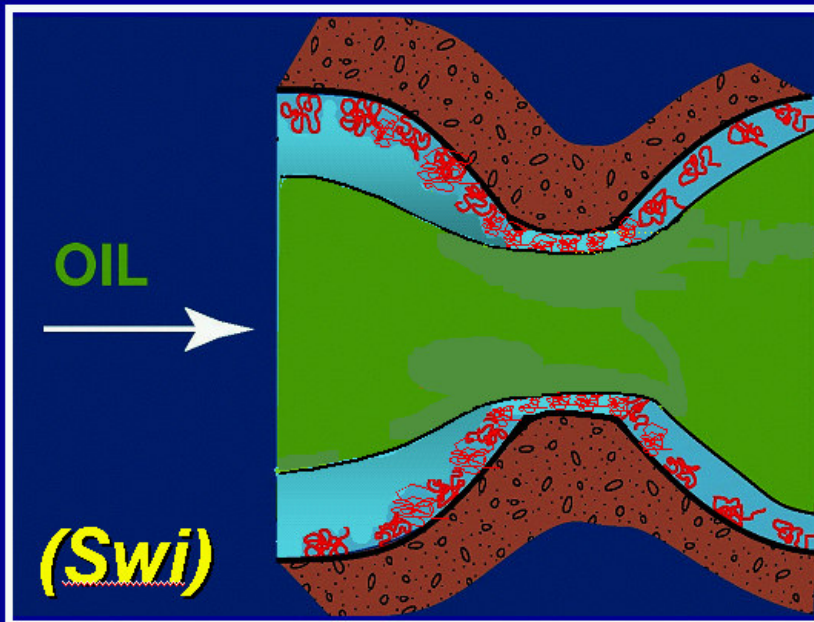
Stabilization of rock cement by "coating" with adsorbed polymer/microgel layer



# Chemical sand consolidation

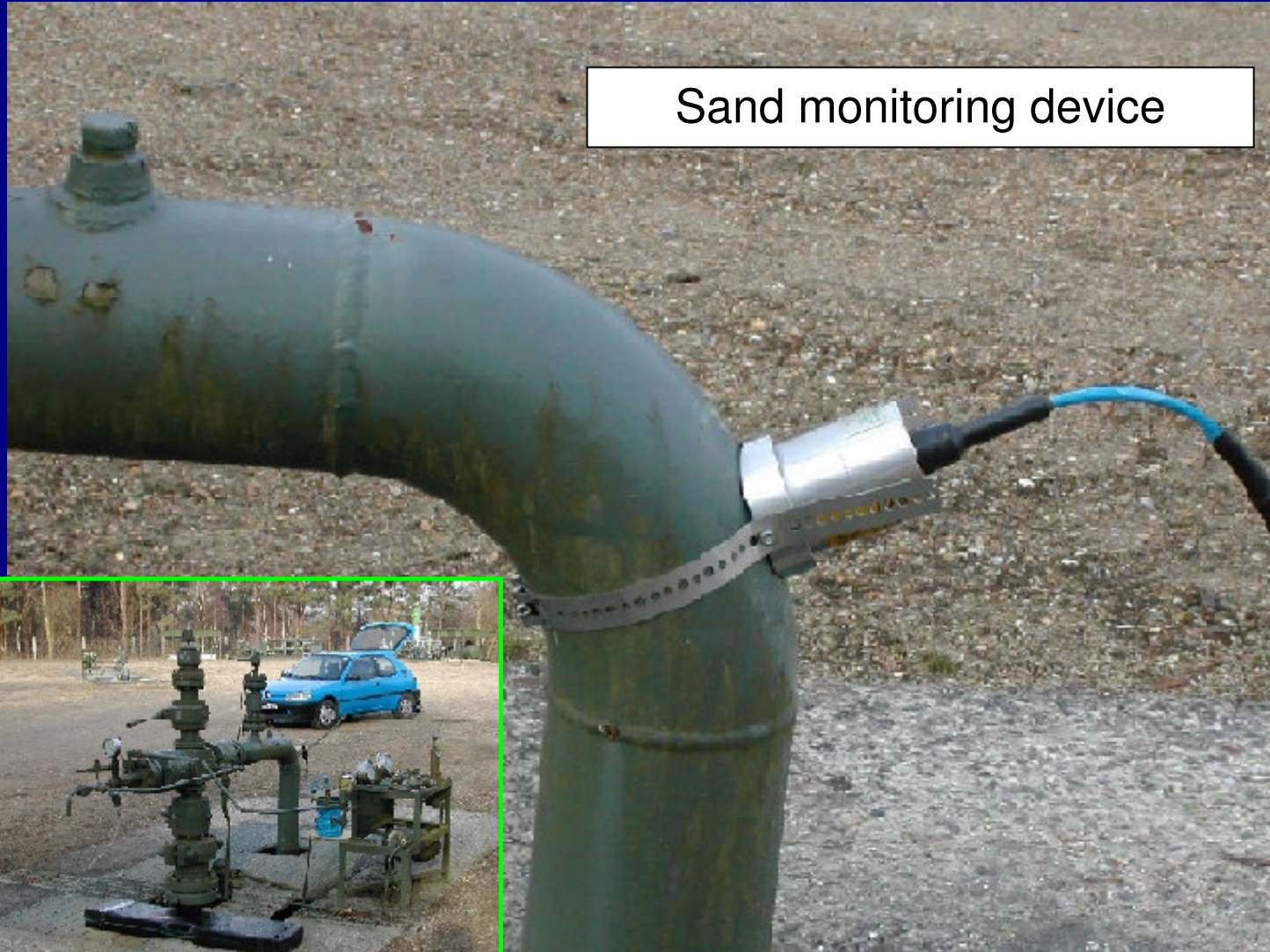
- Two types of products; (1) Oil-based, (2) Water based
- Oil-based product: resins and organo-silanes
- Resins form hard solid compounds
- Formulations have to re-establish oil/gas permeability
- Water-based polymers are environmentally friendly
- Lower consistency than resins, deeper penetration
- Low costs compared to sand control completions

## Advantages of water-based RPM polymer products



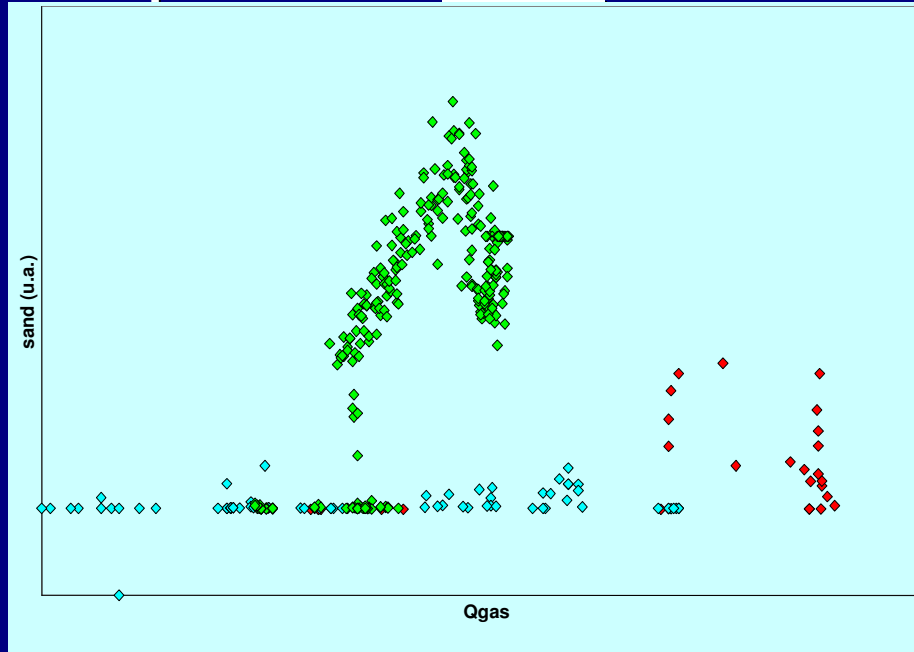
- Treatment has little impact on oil or gas permeability
- Thus, can be injected into existing completion with no risk of well plugging
- Deeper penetration possible than with resins or cement, also much thicker intervals
- Environmentally friendly water based RPM products

# Microgel treatment: effect on sand production



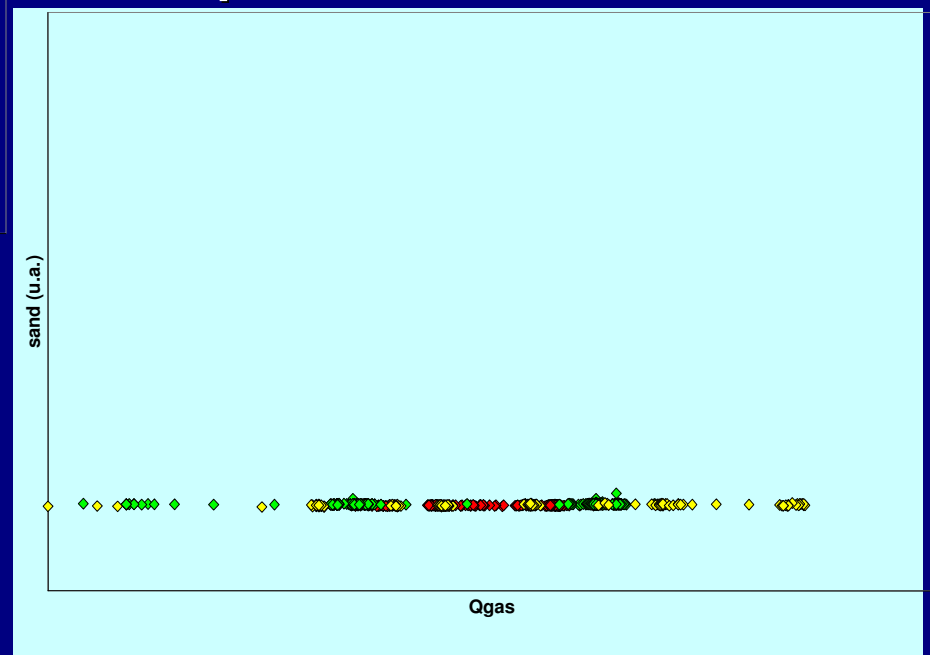
# Effect of Microgel Treatment on Sand Production

Sand production before treatment



Sand impacts at wellhead

Sand production after treatment





# Conclusions

- **Polymer Technology has great potential**
- **Easier and cheaper than other IOR methods**
- **Both EOR (reservoir) & WSO/Sand Control (near-wellbore) applications**
- **New products available (microgels)**
- **Environmentally friendly (water based)**

## Conclusions (II)

- **Broadening field of applications: Sand Control & EOR in Heavy Oil fields**
- **New products in WSO and Conformance, more stable than conventional polymers (microgels)**
- **Lab/Simulations integrated studies improve process control & success rate**