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Society of Petroleum Engineers
Distinguished Lecturer 2006-07 Lecture Season

Challenges on Sand Control and Completions for Productivity in Ultra-Deep Waters

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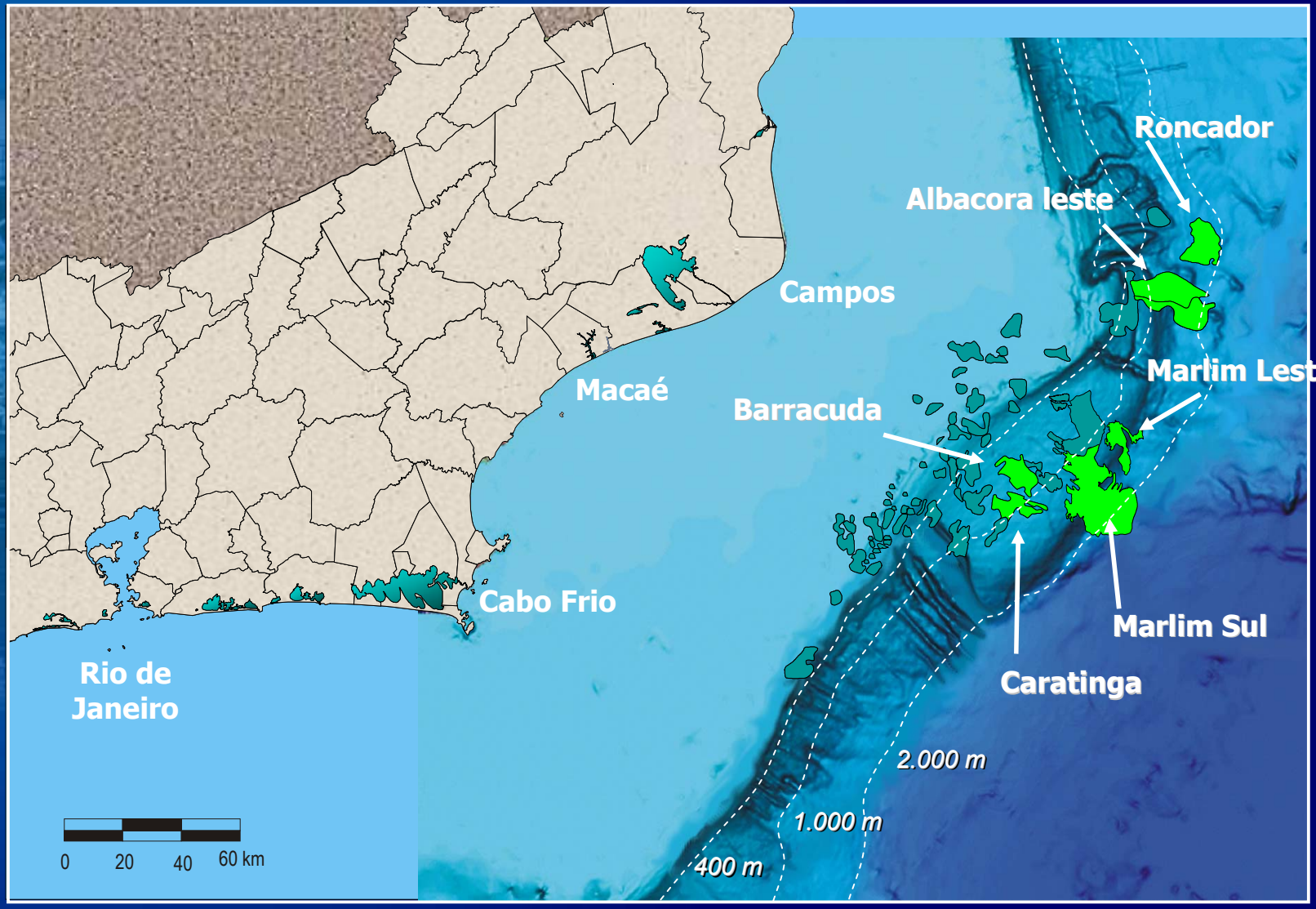
OVER VIEW

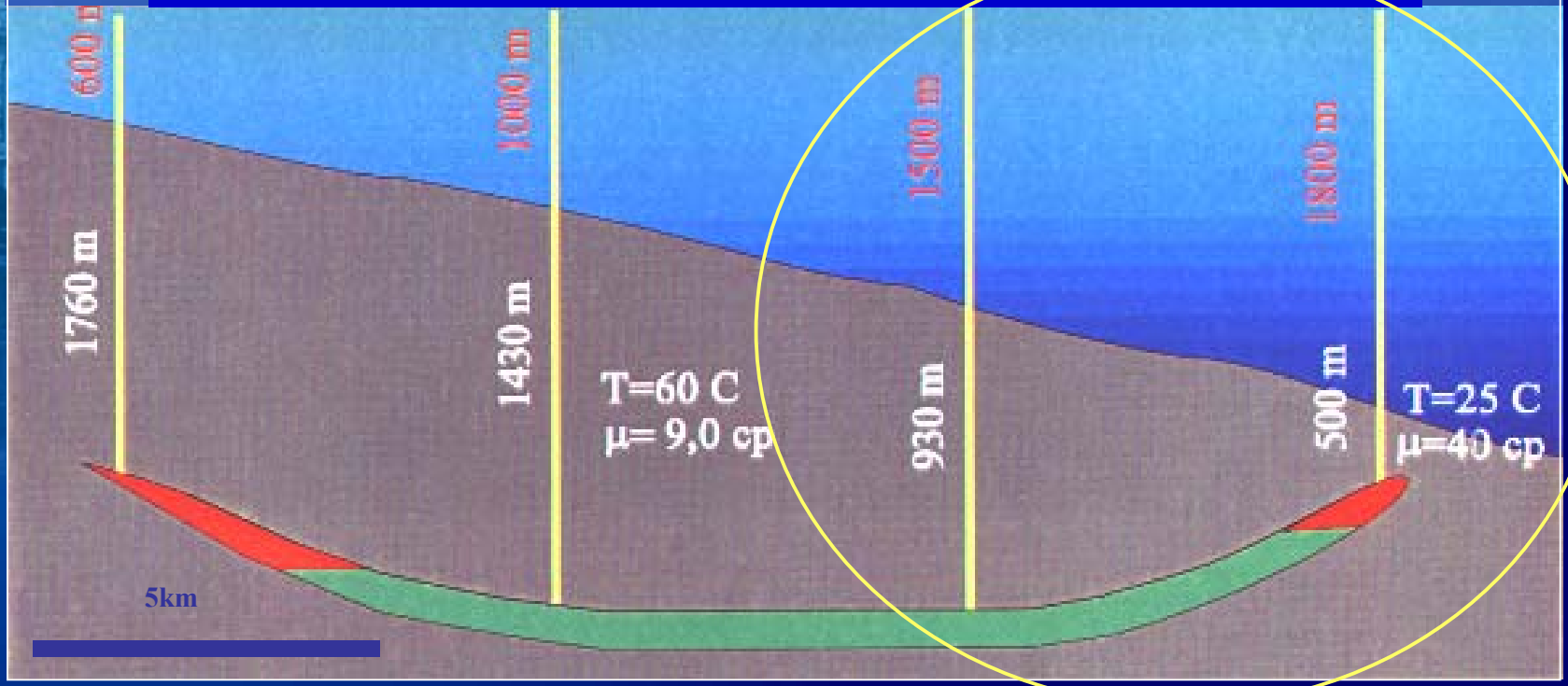
- Reservoir Conditions at Ultra-Deep Waters
- Challenges in Drilling & Completion
- Completion for Productivity
- Sand Control for Deepwater Viscous Oil
- Conclusion Remarks

Ultra-Deep Waters - Campos Basin



Reservoir Conditions at Ultra-Deep Waters

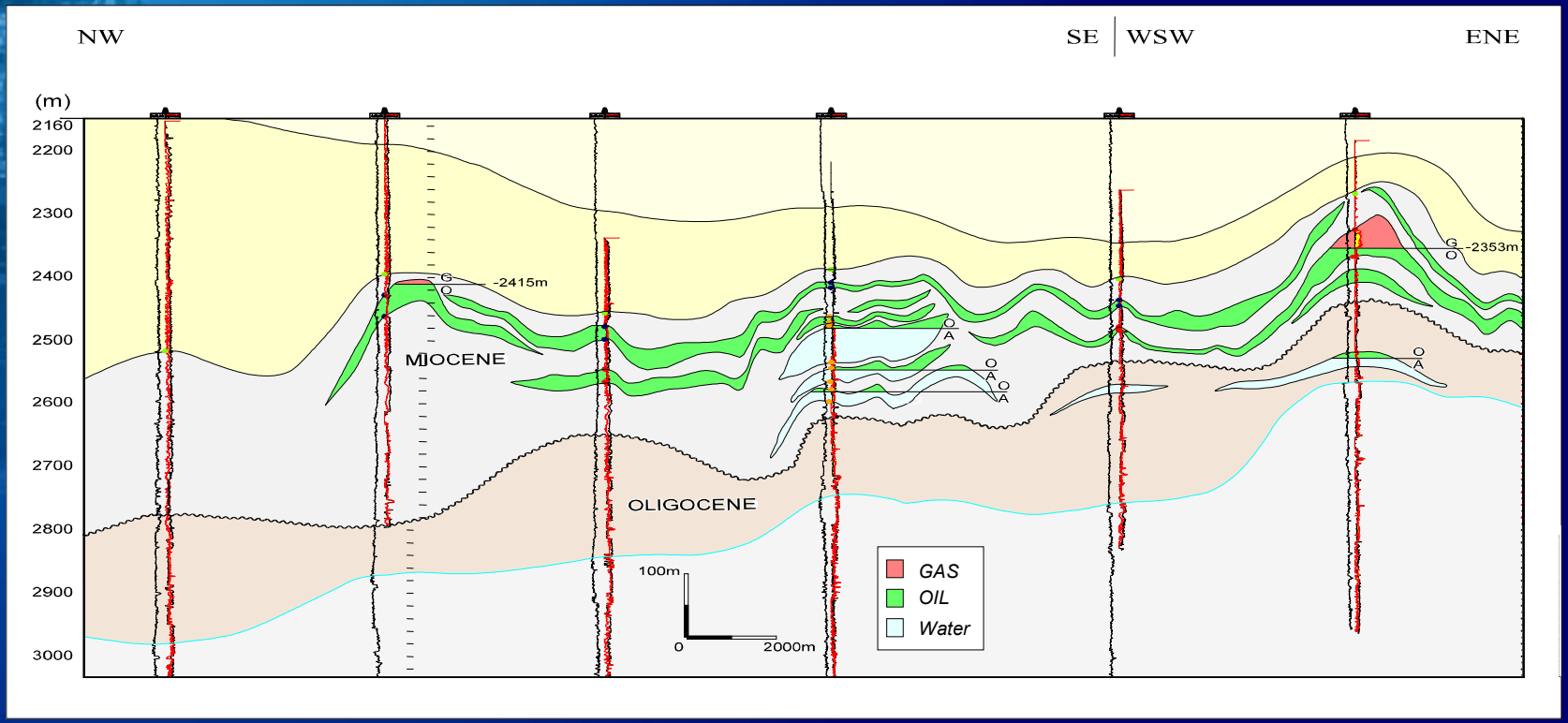
- Deep and ultra-deep waters > 1500 m
- Shallow burial sediments < 1000 m
- Fracture gradient < 0,57 psi/ft
- Temperatures 25 – 60 °C
- Viscosities >20 cP



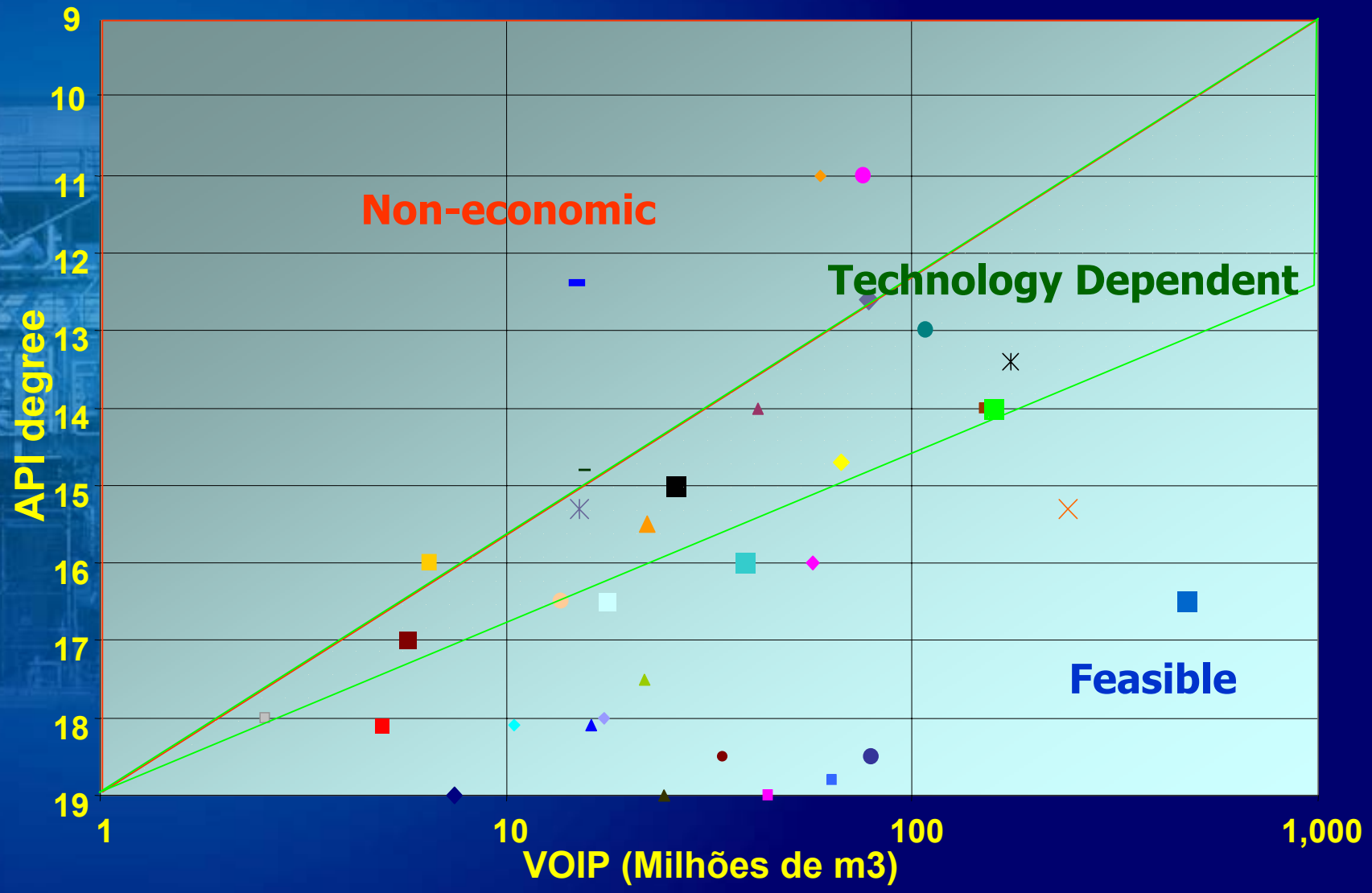
Source: SPE 98342

Reservoir Conditions at Ultra-Deep Waters

- **Turbidite reservoirs:** internal sub-seismic complexity
- **Non-consolidated sands:** non cemented sands
- **Median to Fine sands:** non uniform, high fines content
- **High porosity and permeability**



Economics X Technology



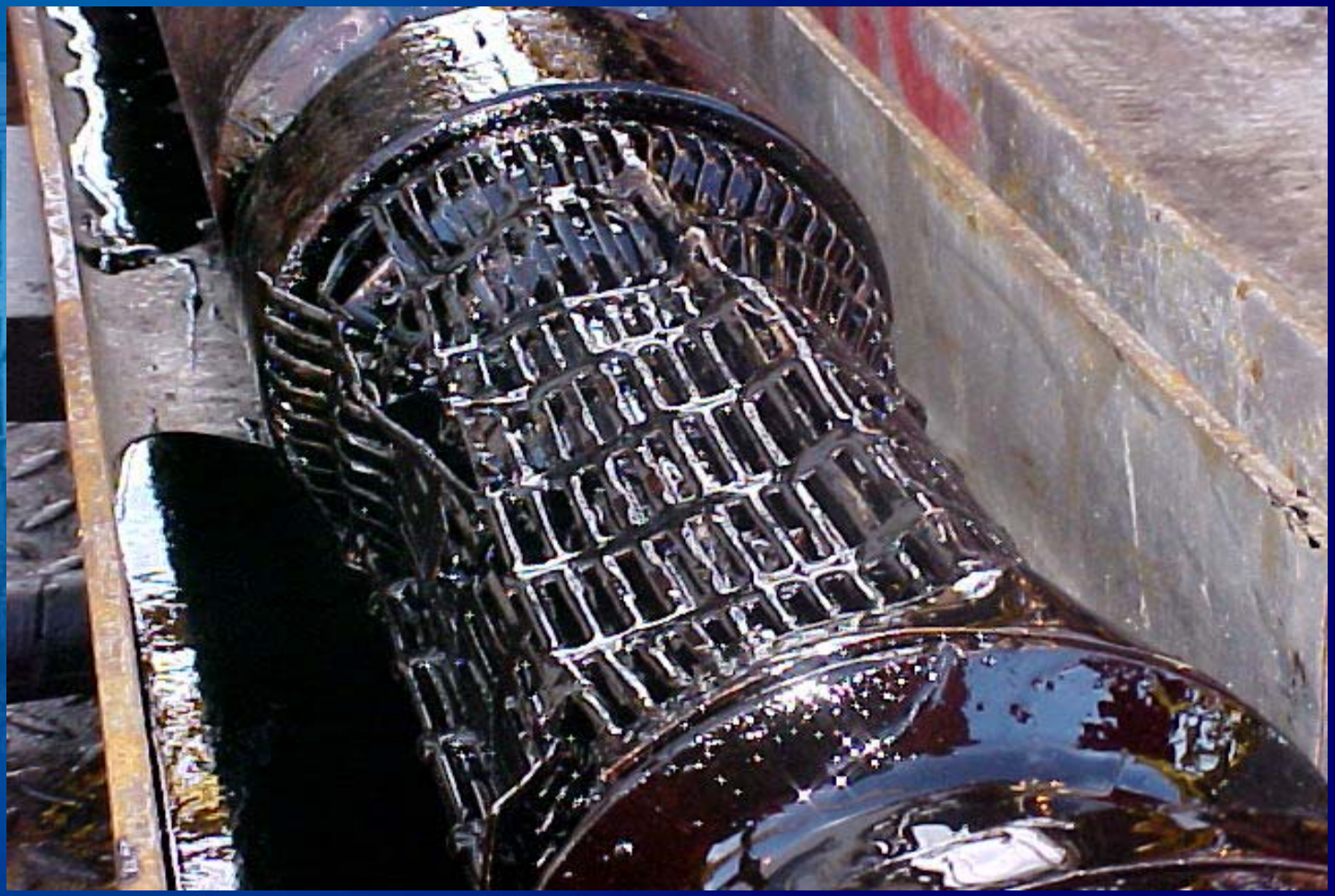
Challenges in Drilling & Completion

- Geological uncertainties
- Narrow operational window for drilling
  - Low absorption pressure
  - Elevated pore pressure
- Presence of reactive shales
  - Needs high performance drilling & completion fluids
- Special wells required
  - Improves reservoir drainage
  - Compensates low oil mobility

Challenges in Drilling & Completion

- Mandatory sand control
- Effective control on water injection and production
  - Needs zonal isolation
- Completion reliability and intervention requirements
  - Offshore submarine operations
- Cold sea bed waters → hydrates, thermal fractures for injectors, etc…

Collapsed ESP intake retrieved from the well

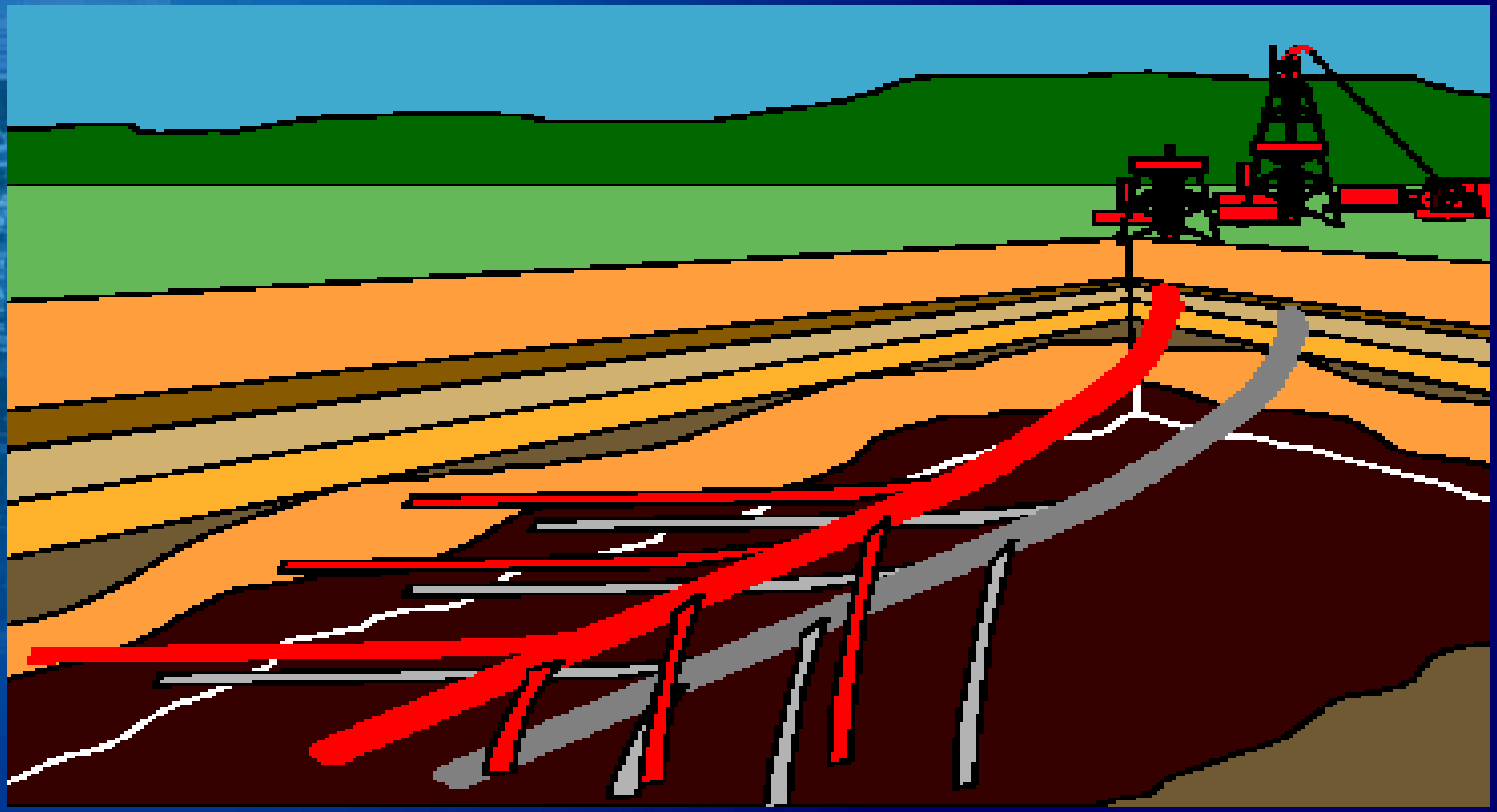


Completion for Productivity

- **Project considerations for Productivity**
  - **Well Geometry Selection**
  - **Oil Production Influx Profile**
  - **Sand Control System Selection**
  - **Control on Water Production and Injection**
  - **Oil Lifting or Sand Control?**

Well Geometry Selection

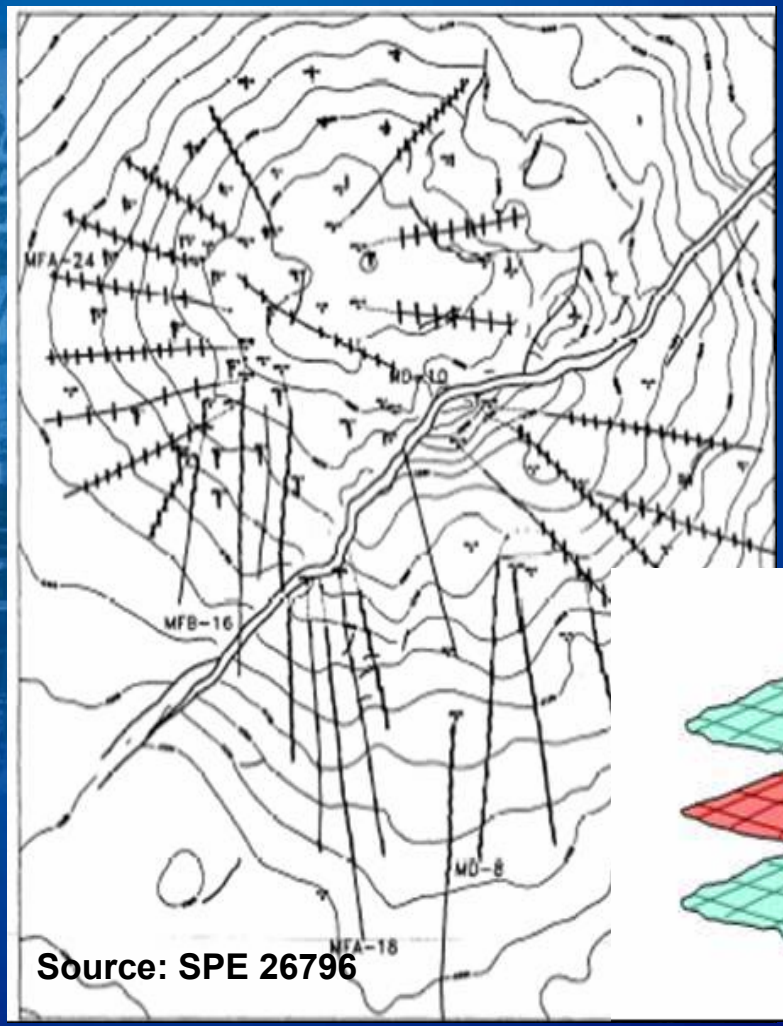
Fishbone multi-laterals



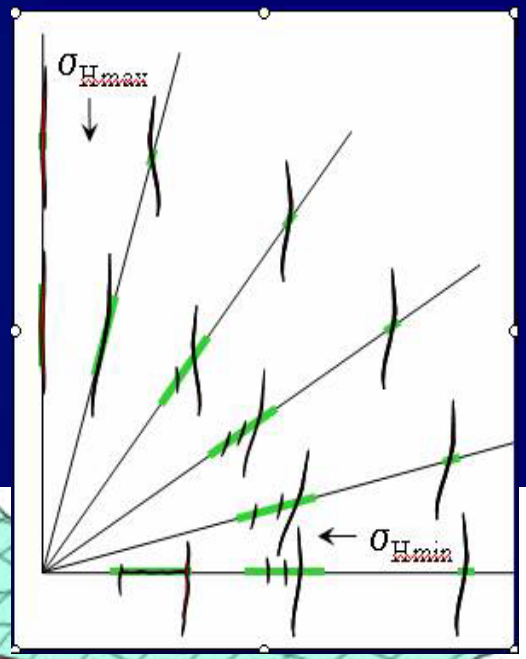
Source: SPE 87966

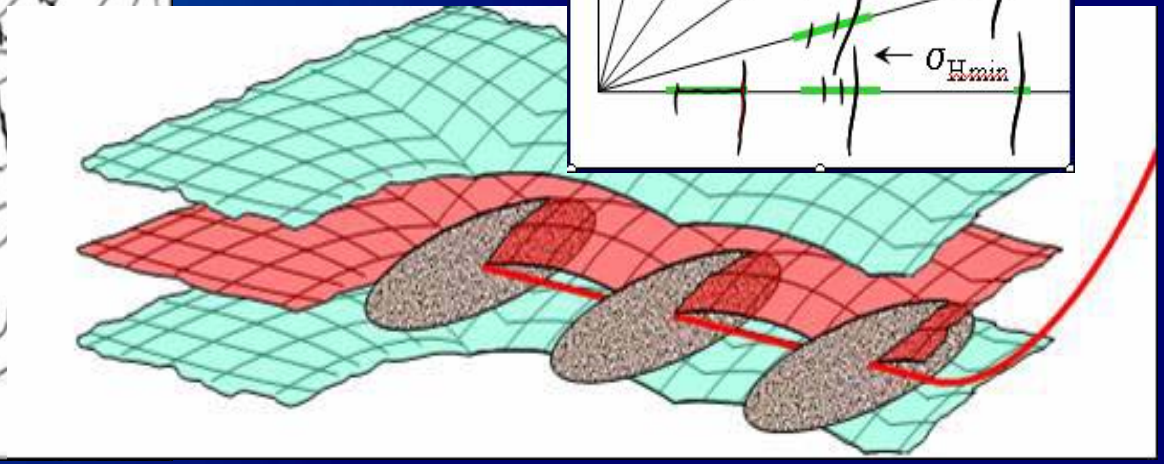
Well Geometry Selection

Horizontal multi-fractured wells



Source: SPE 26796

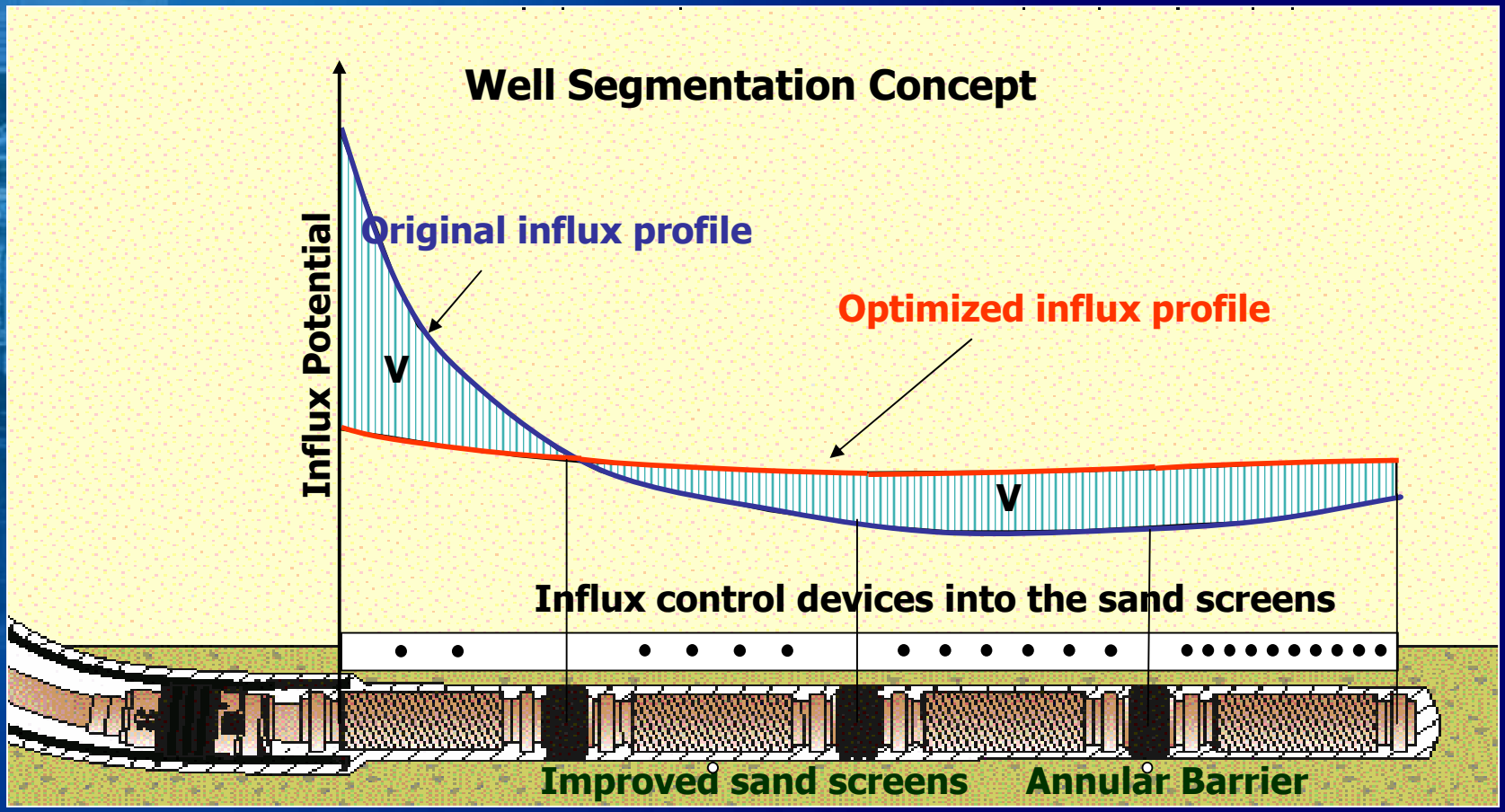




Source: Schlumberger

Oil Production Influx Profile

Single horizontal well with zonal isolation



Source: SPE 98342

Sand Control System Selection

- What are the limits for each sand control method?
  - Installation
  - operation
- What are the implications if some fine sand production is permitted?
  - Flow lines
  - Surface equipments
  - Sand handling and disposal

Control on Water Production and Injection

- How can well productivity be jeopardized due to the early water breakthrough with fines migration?

- How can water injectivity be maximized?

Oil Lifting or Sand Control?

- **Which system will set the rules for the well completion design: sand control or lifting?**

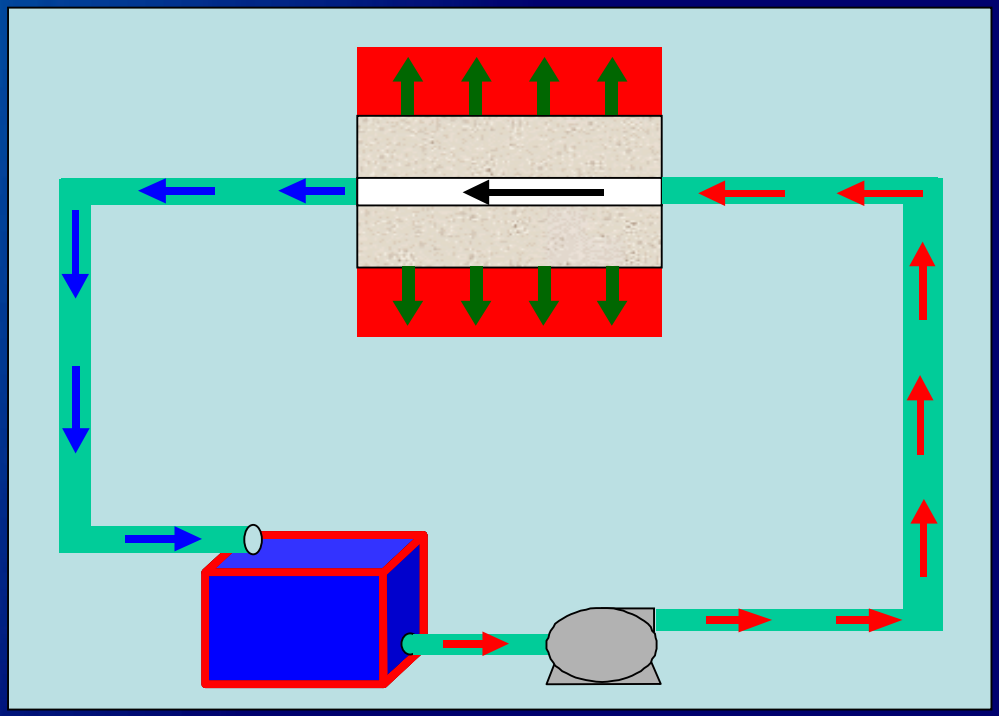
Improvements on well construction

- Extensive use of geo-steering technology
- Single-fluid well construction technology
  - Minimization of the fluid damage
- Sand control system
  - Delivering low pressure drop through the screen
- Water injection maximization
  - Well segmentation concept
- Artificial lifting system tolerant to larger amount of fines (bellow 70 micrometers)

Fluid damage removal and return of permeability

- **Drilling stability and completion efficiency**
  - Highly inhibited drilling fluids
  - Low invasion profile
  - Efficient mud cake easy to remove

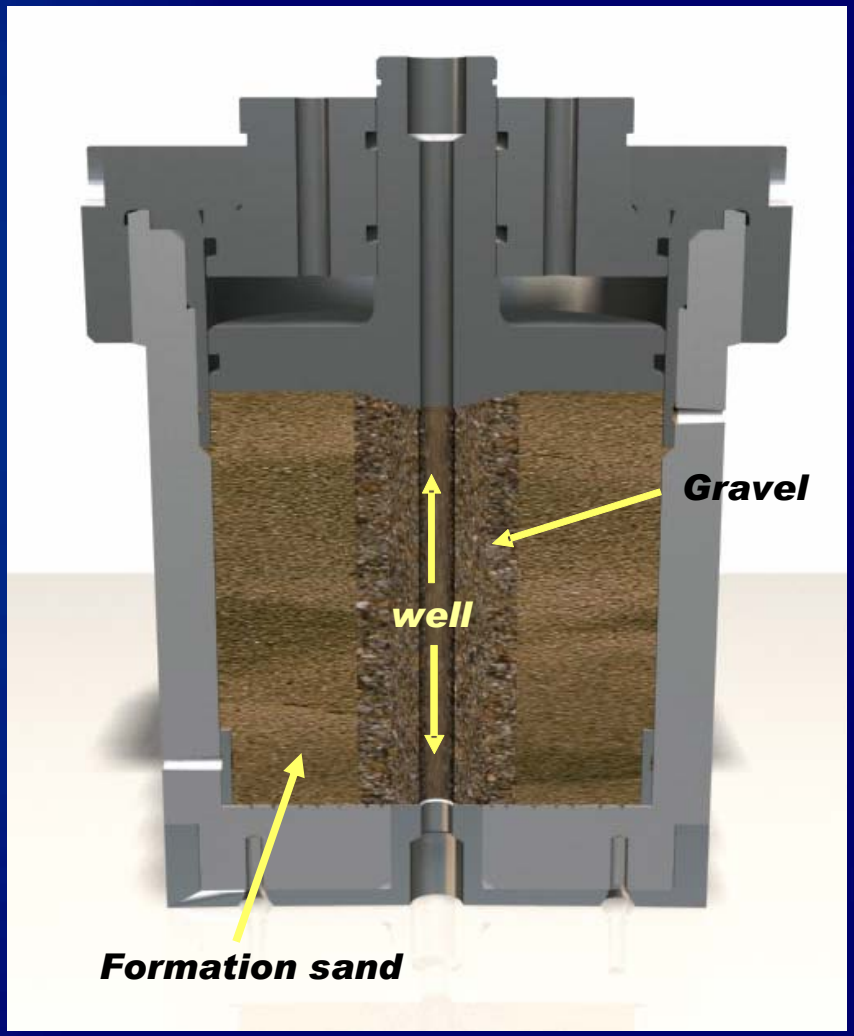
Well simulator



Damage removal and return of permeability

Radial Flow Test Cell

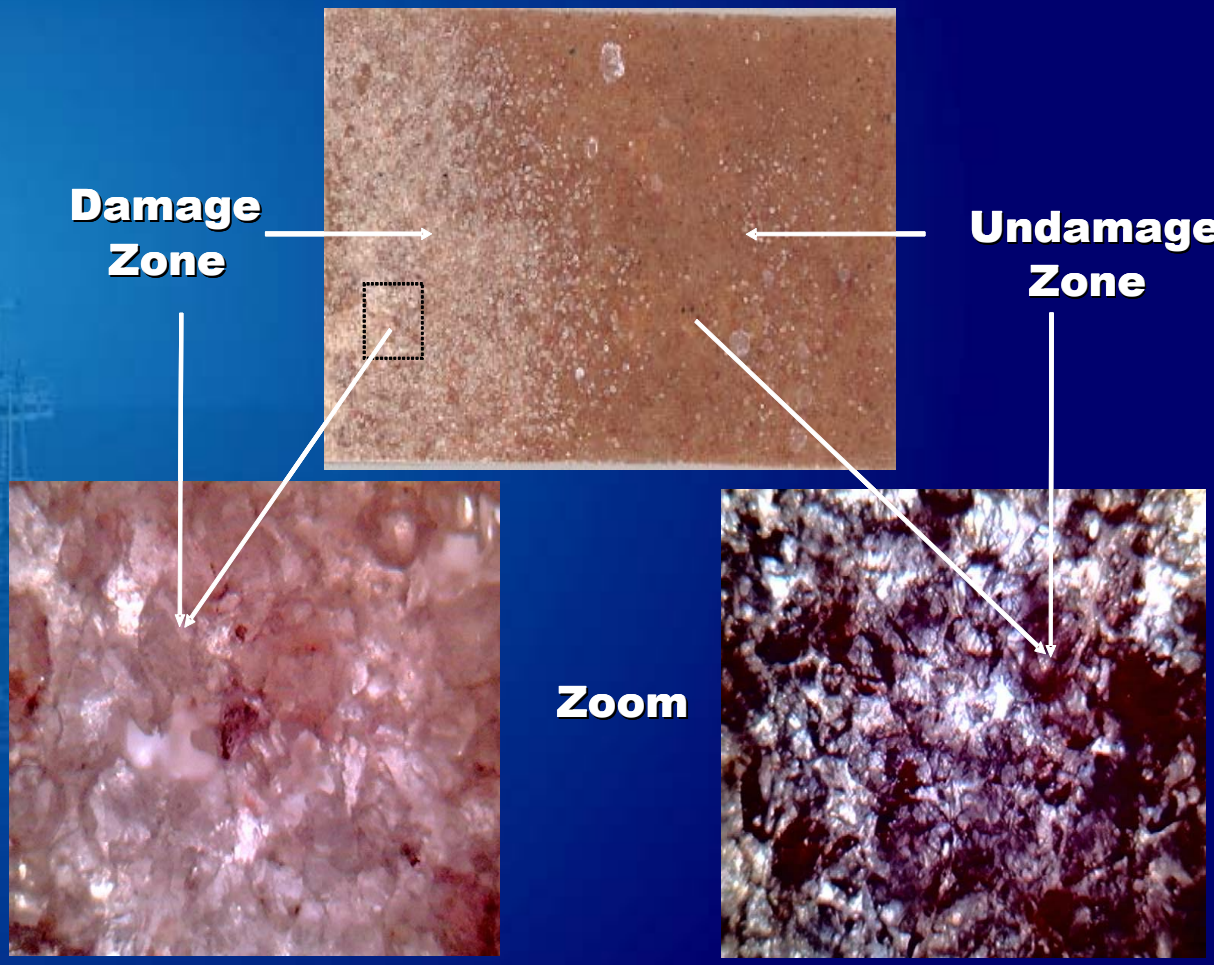
- Mud cake efficiency
- Damage due to filtration
- Mud cake removal
- Fines migration
- Plugging effects



Source: SPE 95025

Damage removal and return of permeability

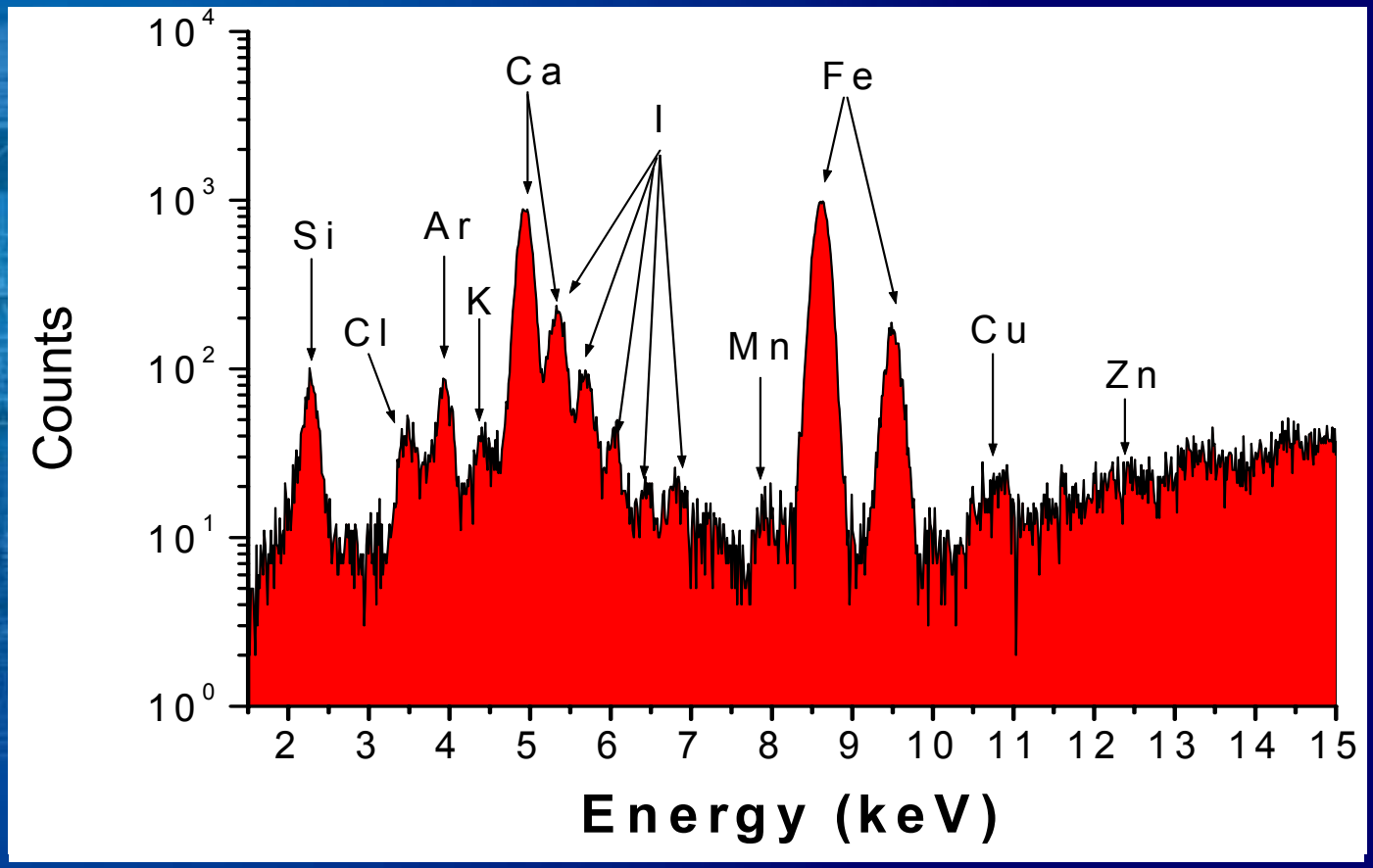
Drill-in Fluid Invasion - bridging agent and polymers



Source: SPE 95025

Damage removal and return of permeability

Typical spectrum for uncosolidated sandstone



Source: SPE 95025

Sand Control for Deepwater Viscous Oil

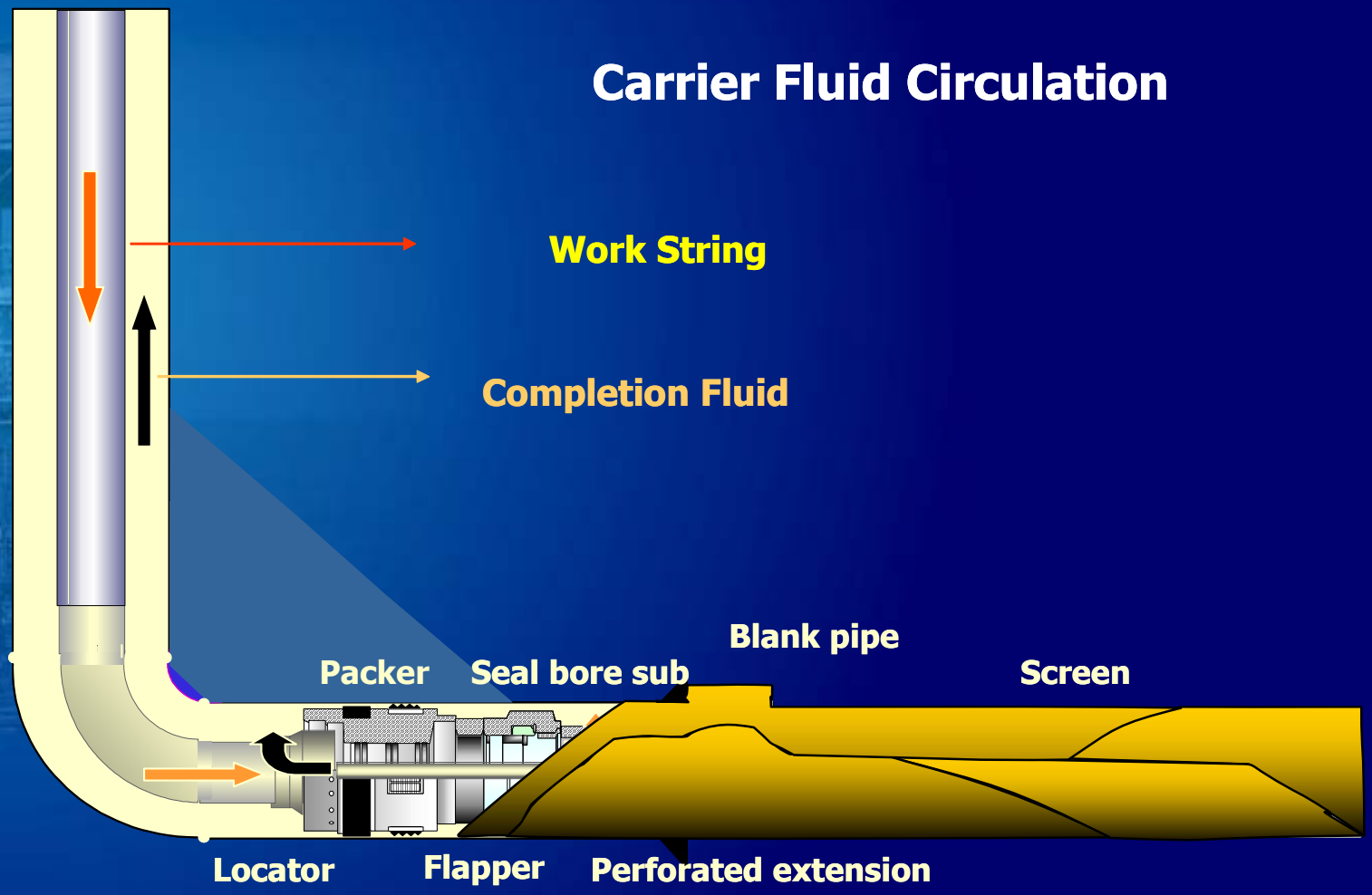
- **Horizontal Open Hole Gravel Pack**
  - Most used sand control method
- **Stand Alone Screens**
  - Wire Wrapped
  - Meshed (single or multilayer)
  - Expandable
- **Frac & Pack**
  - Not used above 60 degree

Sand Control for Deepwater Viscous Oil

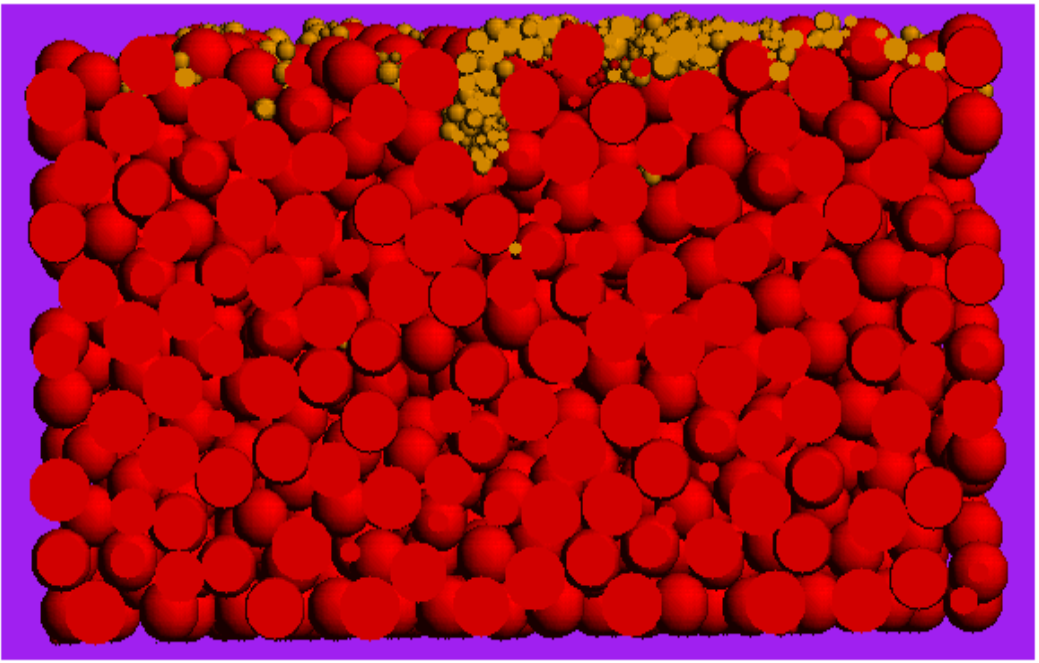
- **Open Hole Gravel Pack**
  - Carrier fluid compatible with the mud cake
  - Pressure at the casing shoe limited by the frac pressure
  - Light propant
  - Gravel impairment
- **Stand Alone and Expandable Screens**
  - Screen performance tests
    - Coupon Tests
    - Tangential tests
    - Full scale tests

Horizontal Open Hole Gravel Pack

Carrier Fluid Circulation

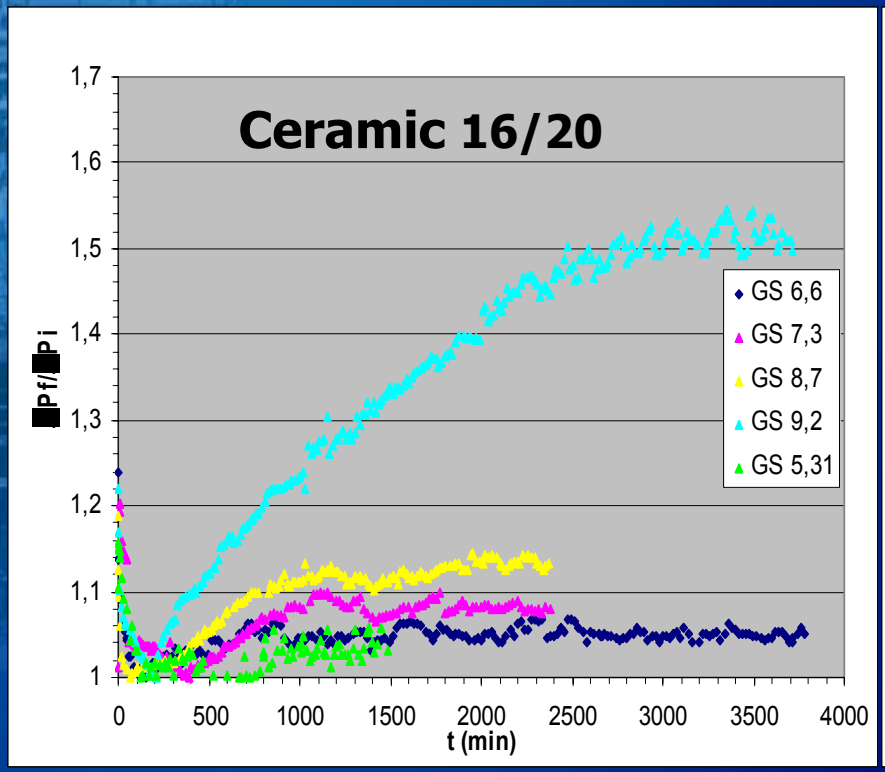


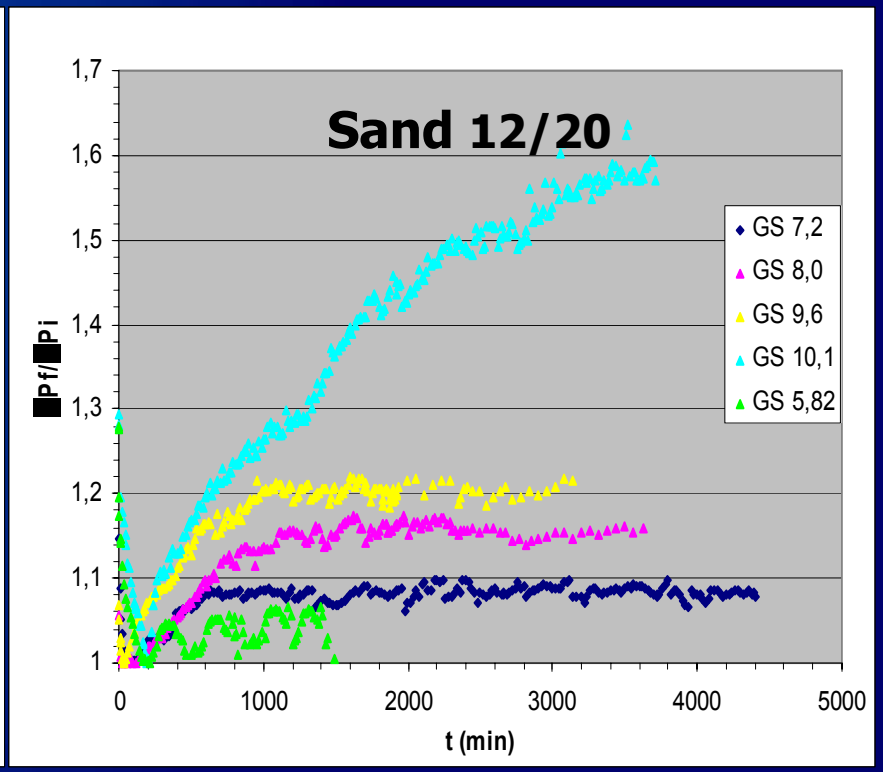
Gravel Pack Impairment Test



Gravel Pack Impairment Test

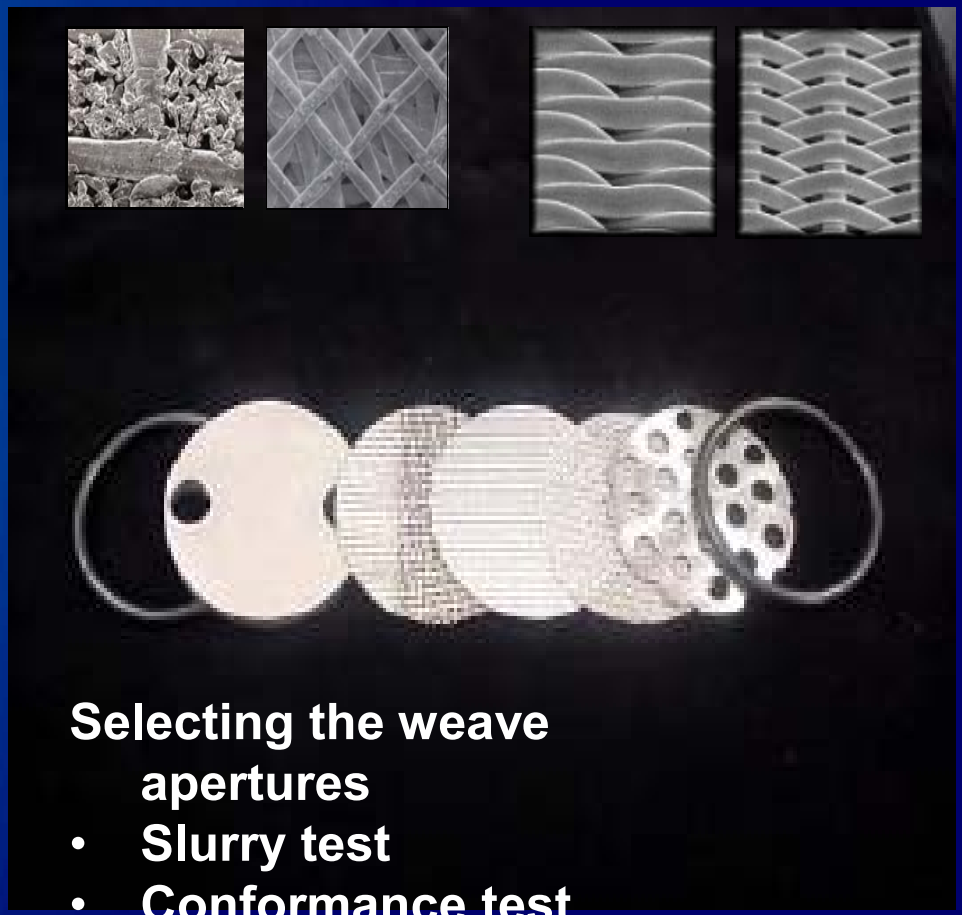
Some Results





Screen Performance tests

Coupon Test



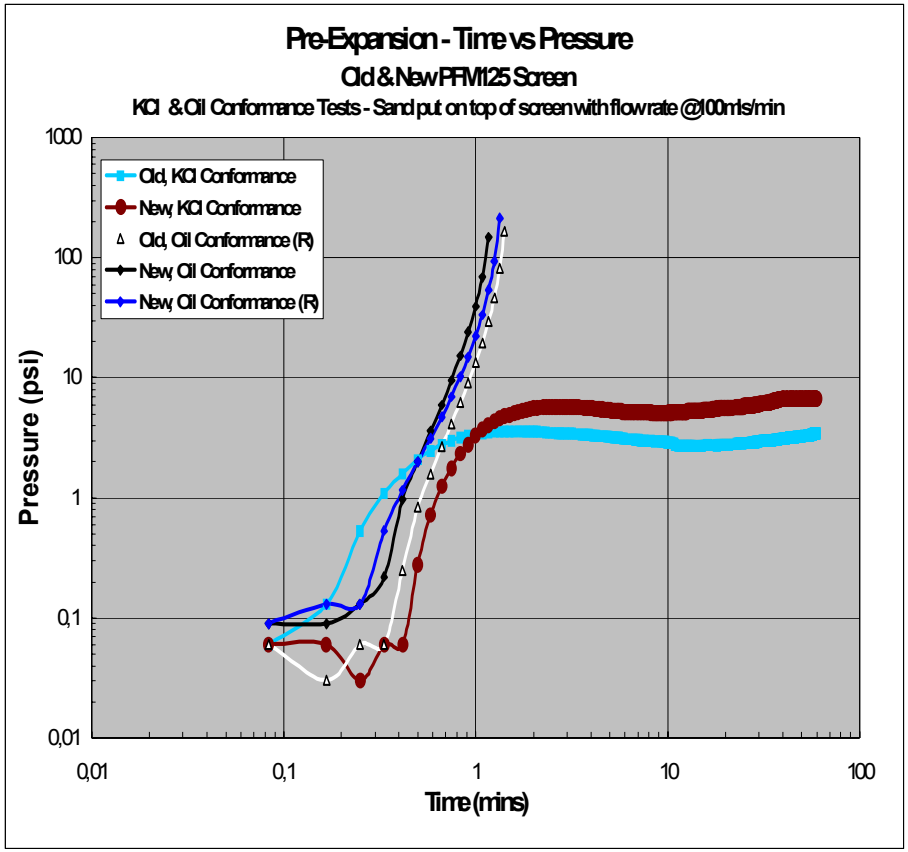
Selecting the weave apertures

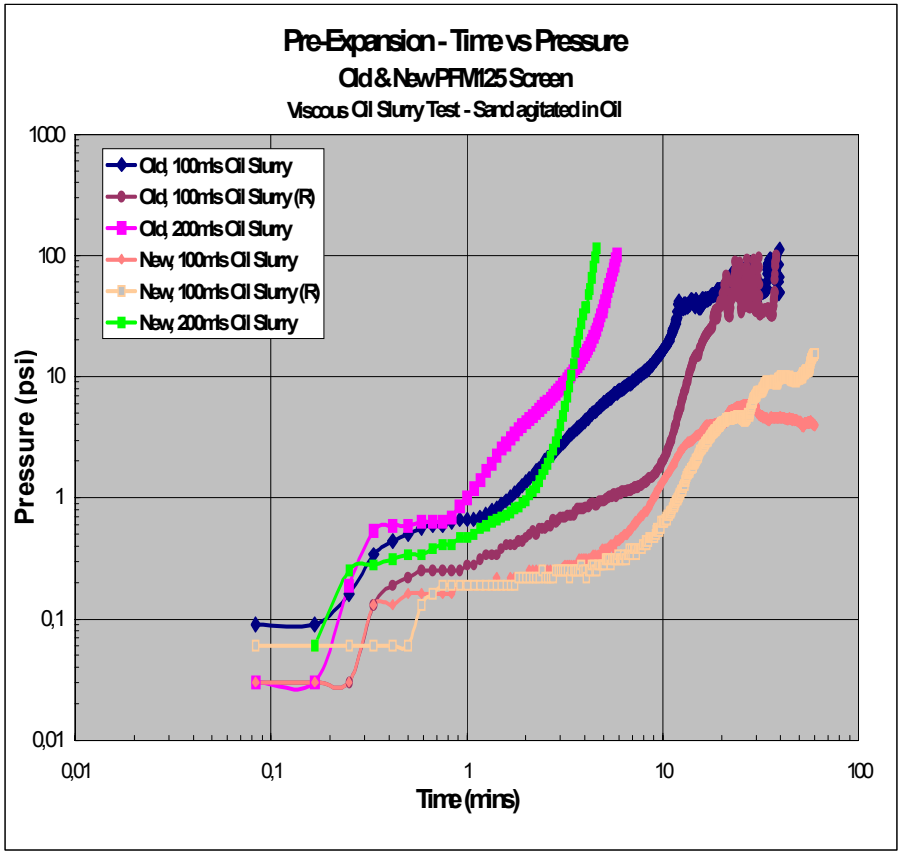
- Slurry test
- Conformance test

Source: SPE 98342

Screen Performance tests

Results for the Coupon test

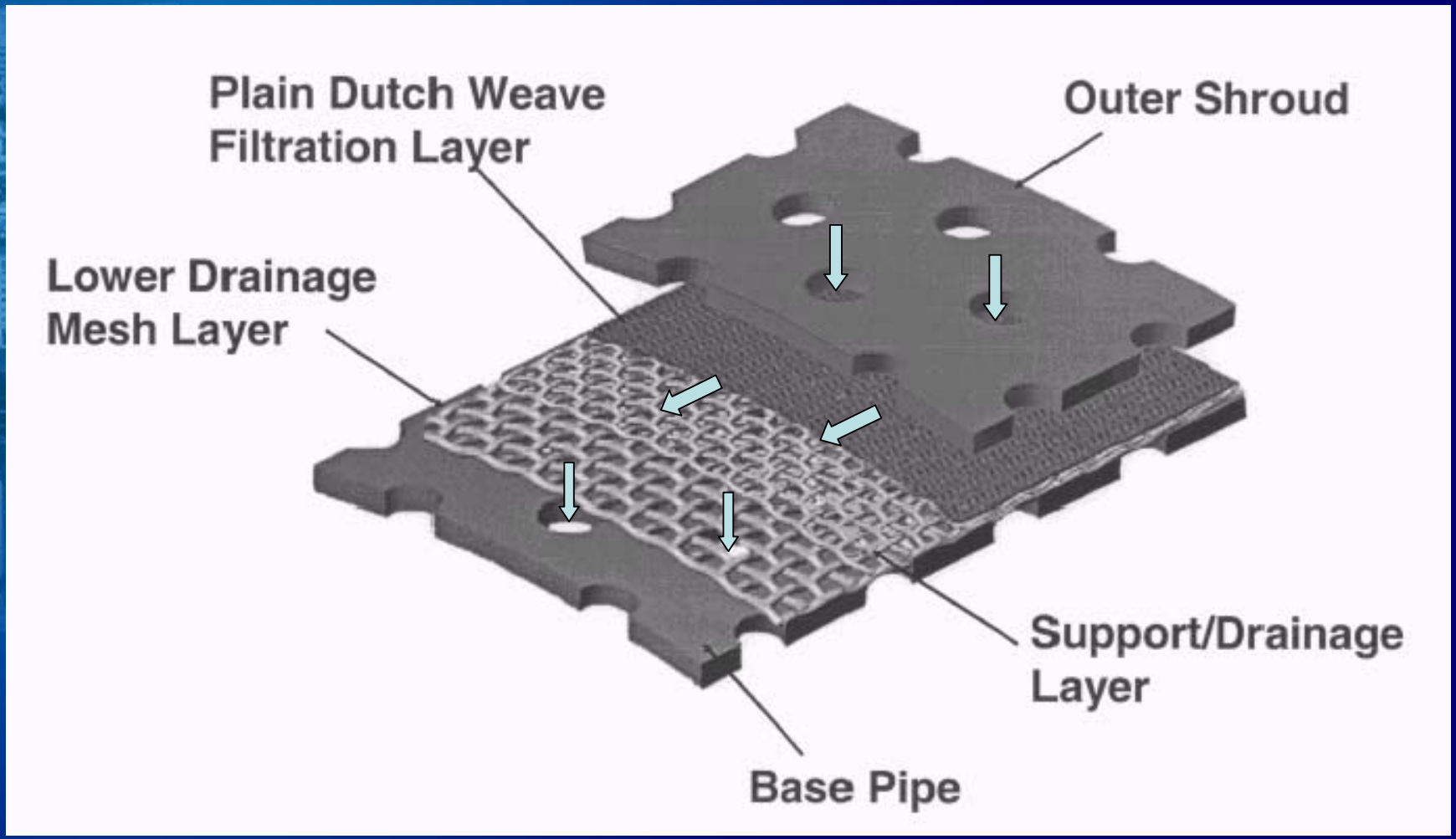




Source: SPE 98342

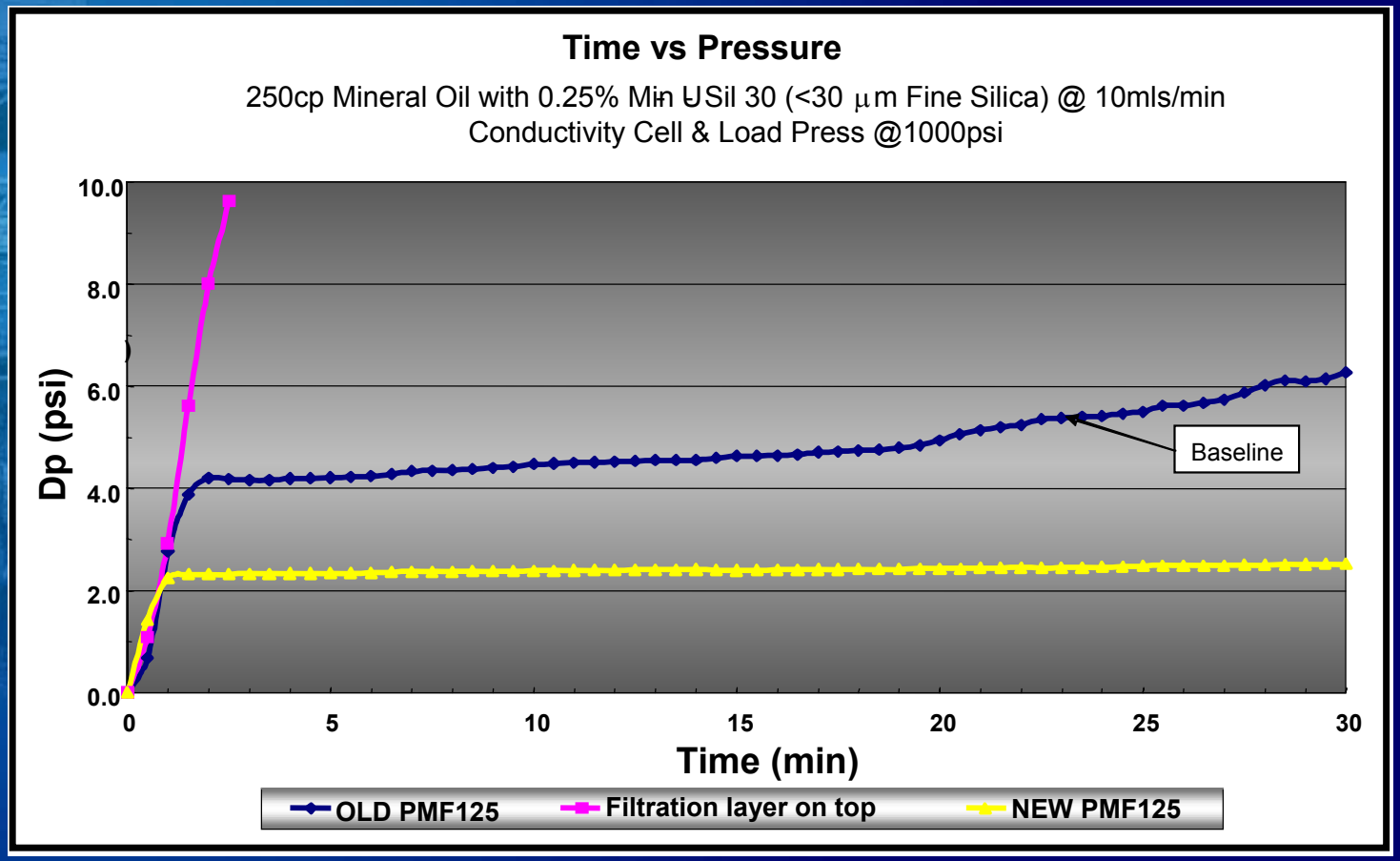
Screen Performance tests

Transversal Flow Test



Screen Performance tests

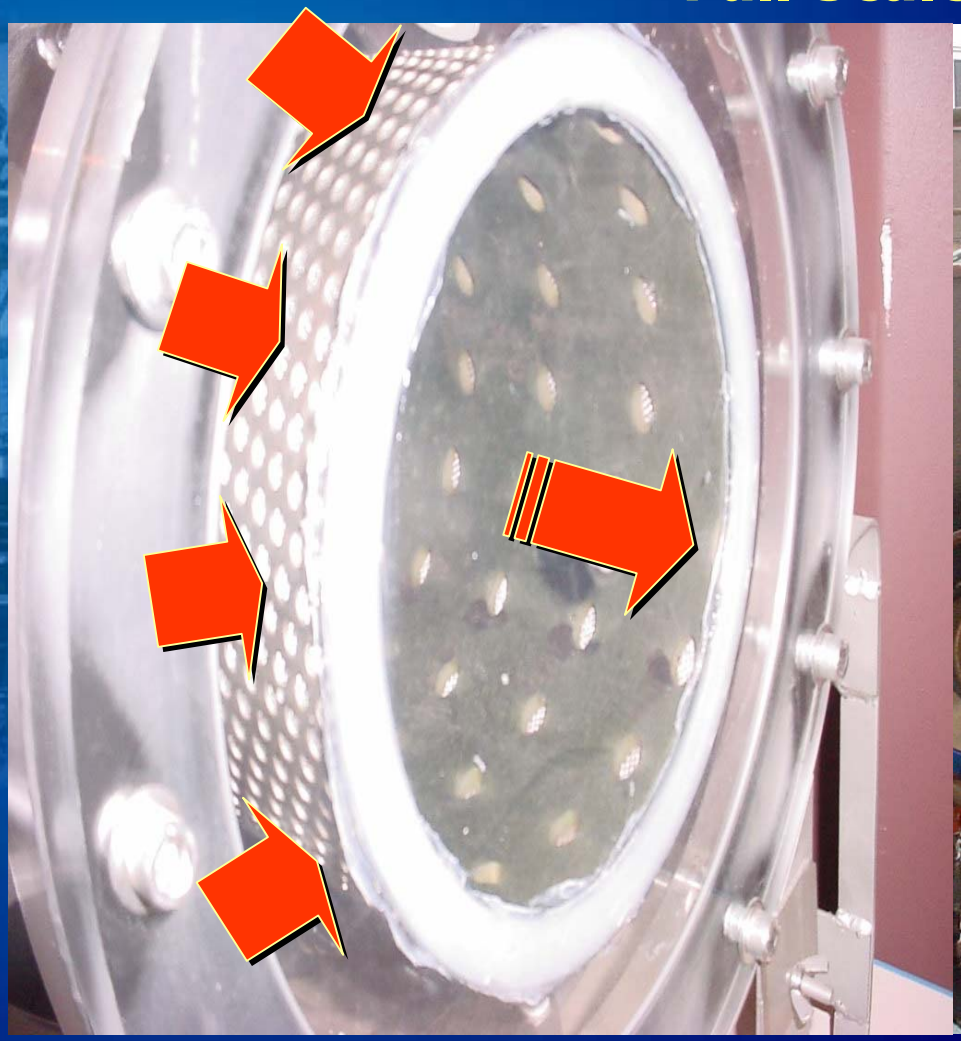
Results for the Tangential Flow Test

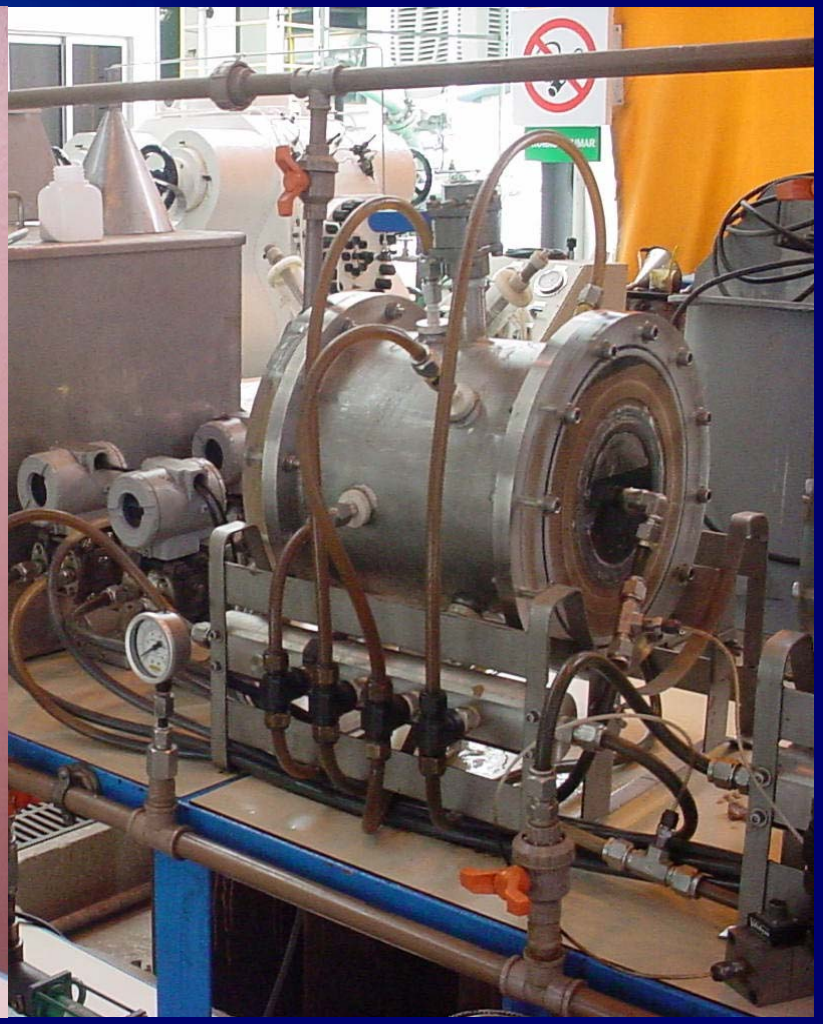


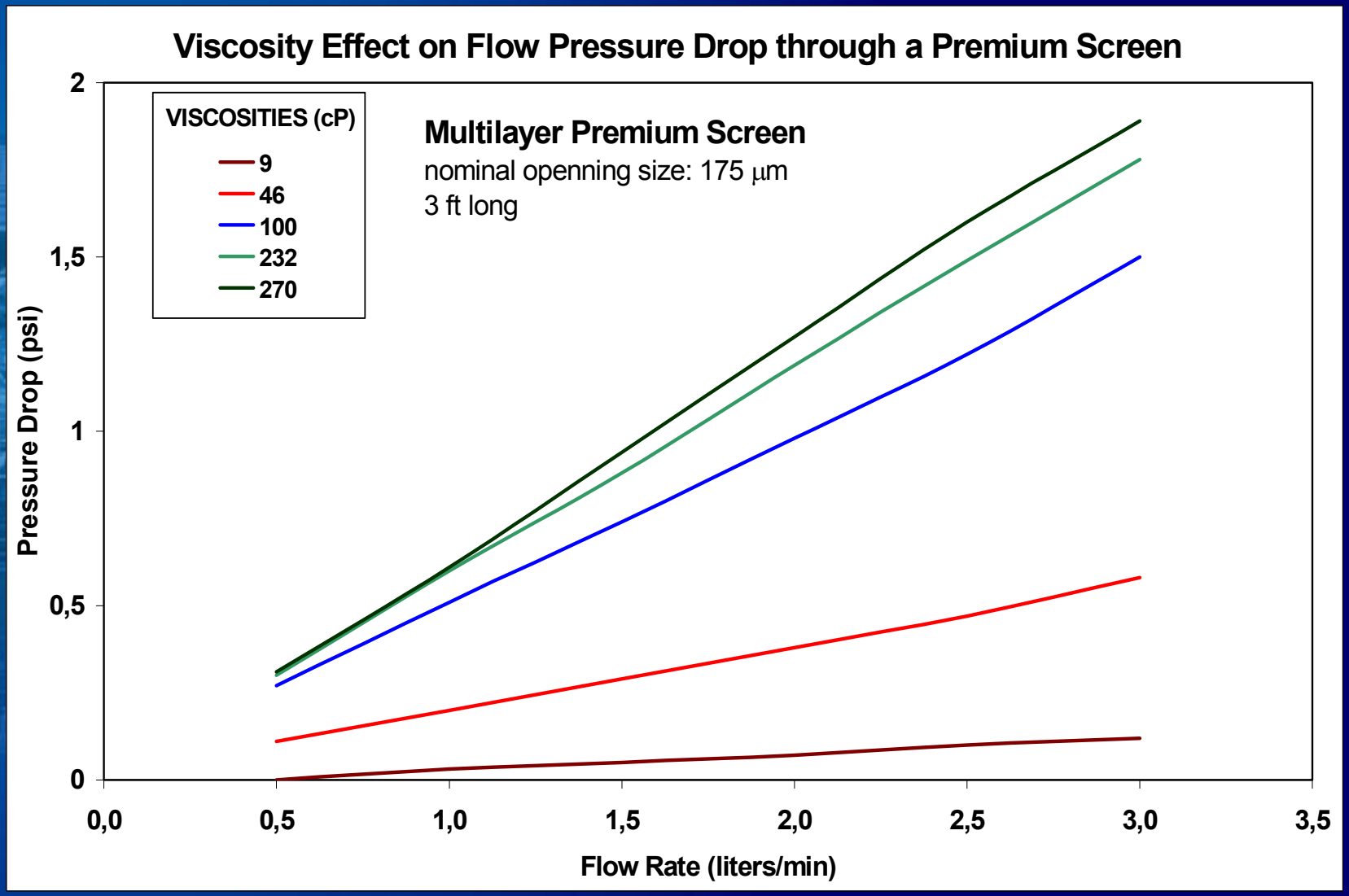
Source: SPE 98342

Screen Performance tests

Full Scale Test

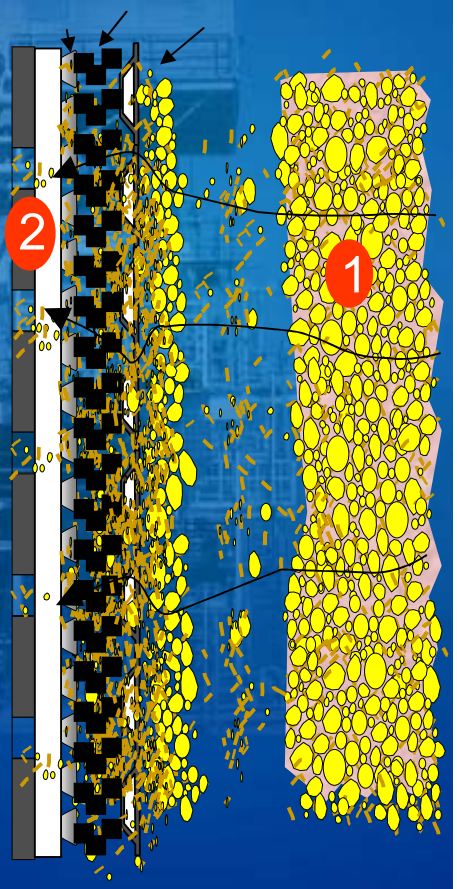


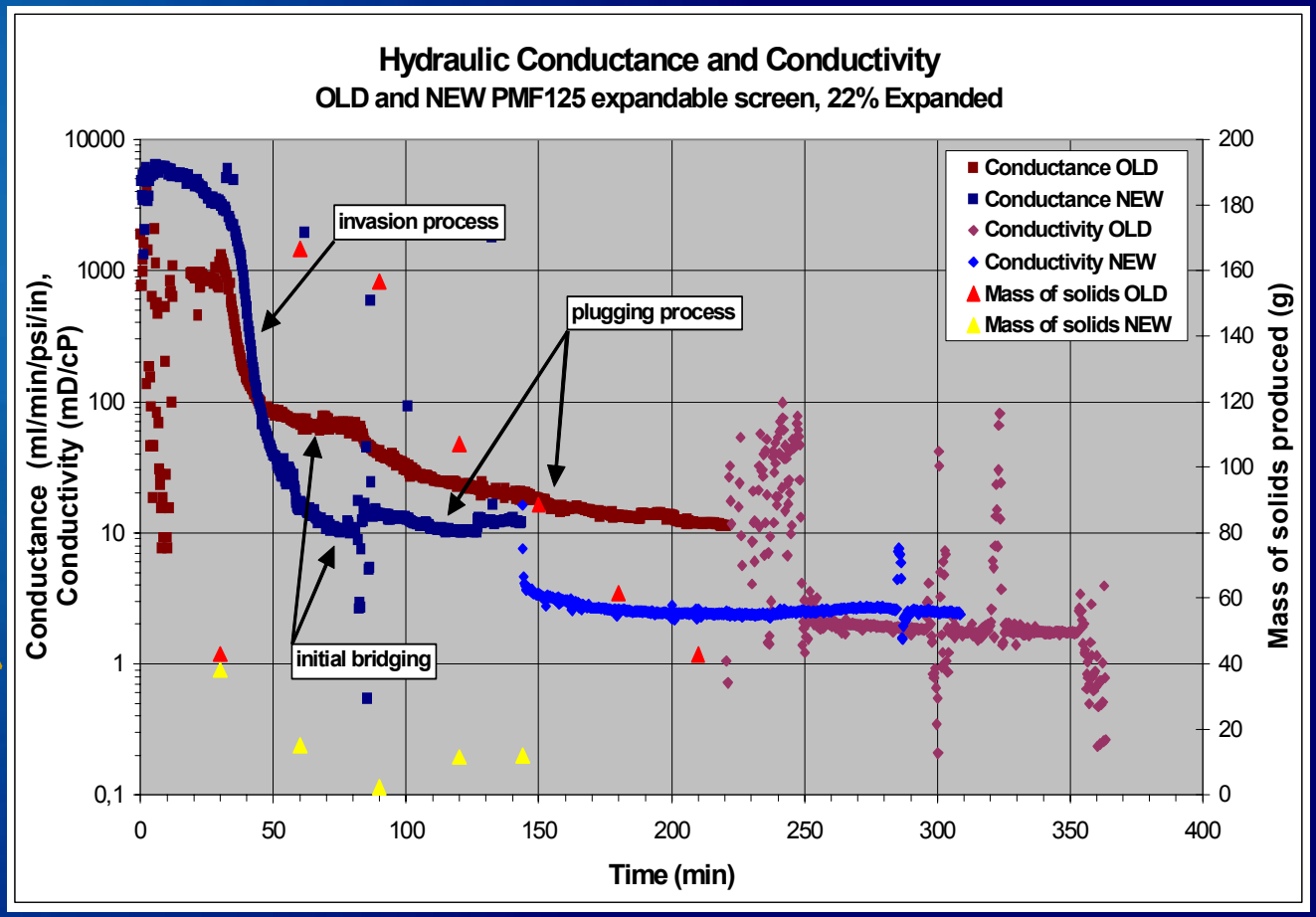



Viscosity Effect on Flow Pressure Drop through a Premium Screen
VISCOSITIES (cP)
9
46
100
232
270
Multilayer Premium Screen
nominal openning size: 175 µm
3 ft long
Pressure Drop (psi)
2
1,5
1
0,5
0
0,0
0,5
1,0
1,5
2,0
2,5
3,0
3,5
Flow Rate (liters/min)

Screen Performance tests

Results for the Full Scale Test





Screen Performance tests

1. Slurry test ⇨ screen conductance

- How easily oil flows along a certain path through a porous material

$$G = \frac{Q}{\Delta P}$$

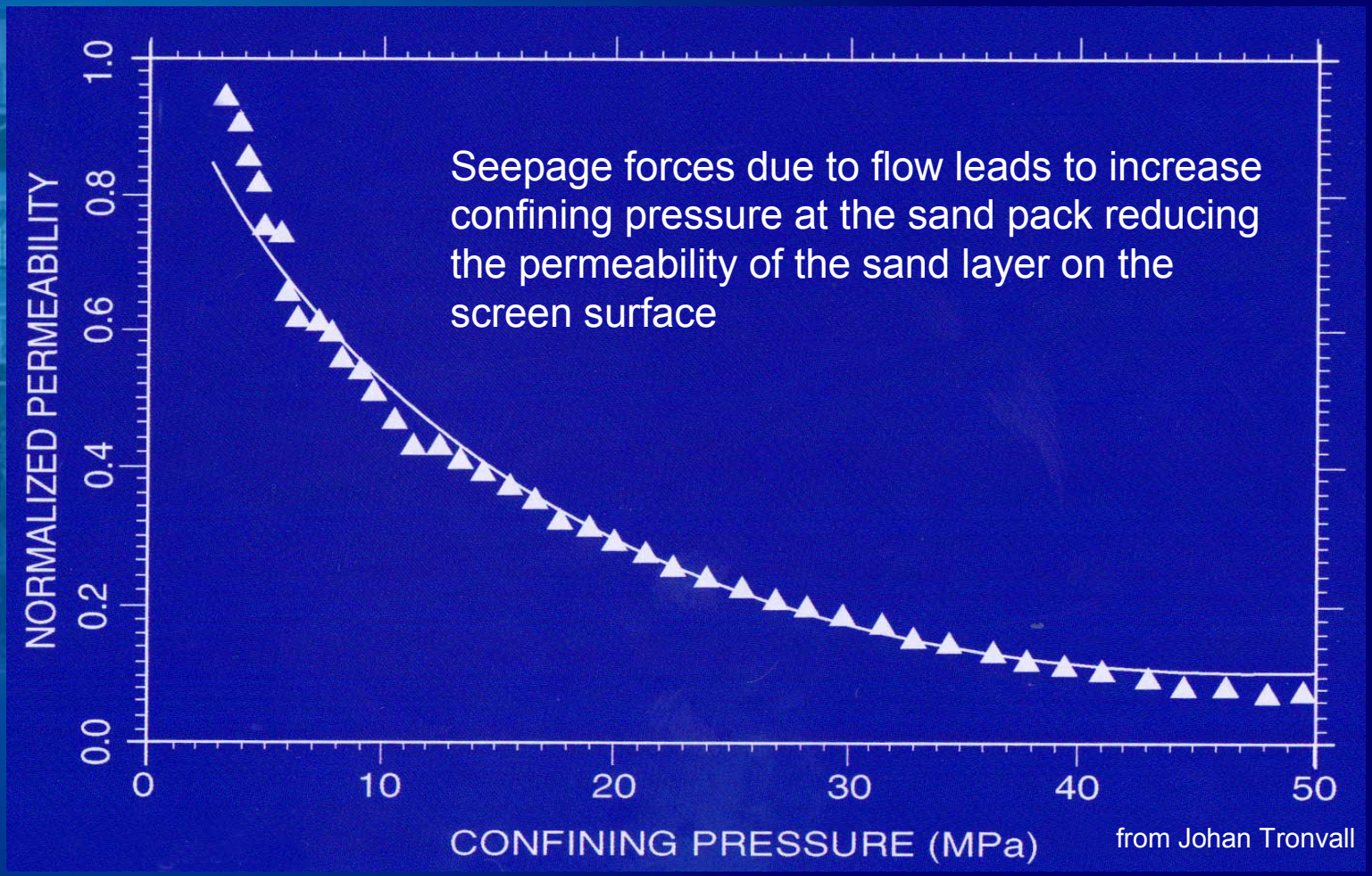
2. Conformance test ⇨ sand pack conductivity

- How well a porous material accommodates the flux of oil

$$\lambda = \frac{K}{\mu} = 15.34\left(\frac{G}{l}\right) Ln\left(\frac{Rac}{Rs}\right)$$

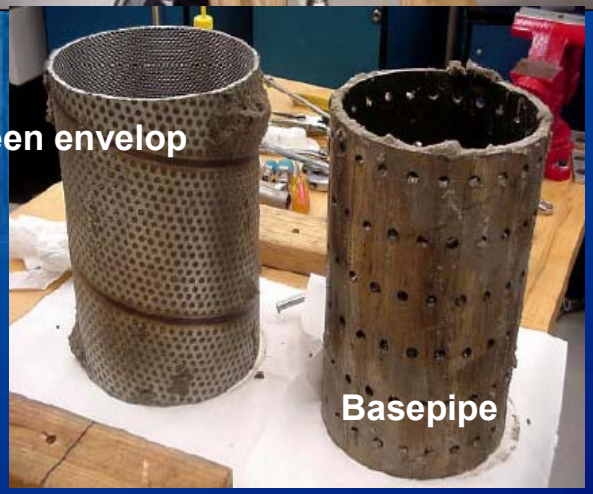
Sand Control for Deepwater Viscous Oil

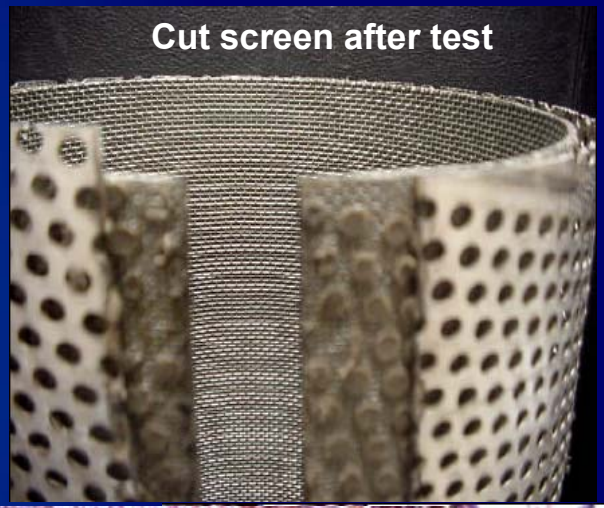
Compaction Induced by fluid flow

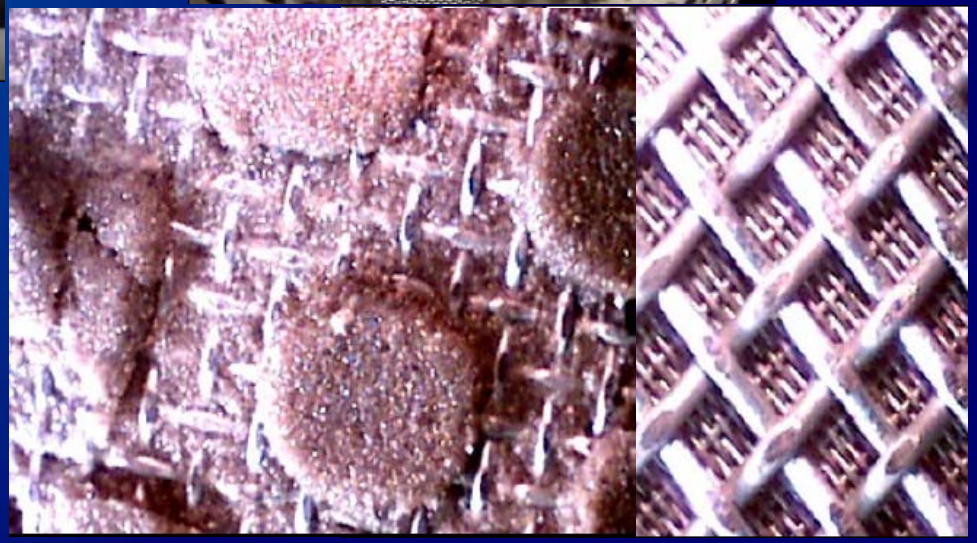


Screen Performance tests

Cell breakdown







Weave surface at the shroud side and internaly (10X)

Screen Removed from Well

Conclusion Remarks

- Improvements on the performance of horizontal wells come from proper well design and completion practices. They also depend on understanding the influence and effects of each productivity factor.

- Where traditional completion solutions have not given good results, special or "designed for" solutions need to be conceived, tested and applied.

Conclusion Remarks

- Viscous Oil exploitation in offshore ultra-deep waters is a challenge that can change the way well construction is done.
- Well geometry, water production control and oil influx profile have high influence on productivity.
- Drilling fluid compatibility, mud cake removal and return of permeability can impact the efficiency of completion.

Conclusion Remarks

- **Screen performance is highly affected by its construction, particles size distribution, amount of migrating fines produced and oil viscosity.**

Thank you for your attention!

Questions?