EOR Optimization Techniques and Associated Reservoir Diagnostics for Extending the Life of Unconventional Plays

Swathika Jayakumar

ProTechnics, Div. of Core Lab

Outline

- Setting the stage
- Challenges
- Diagnostics
  - Primary Completion
  - Conventional EOR
  - Unconventional EOR

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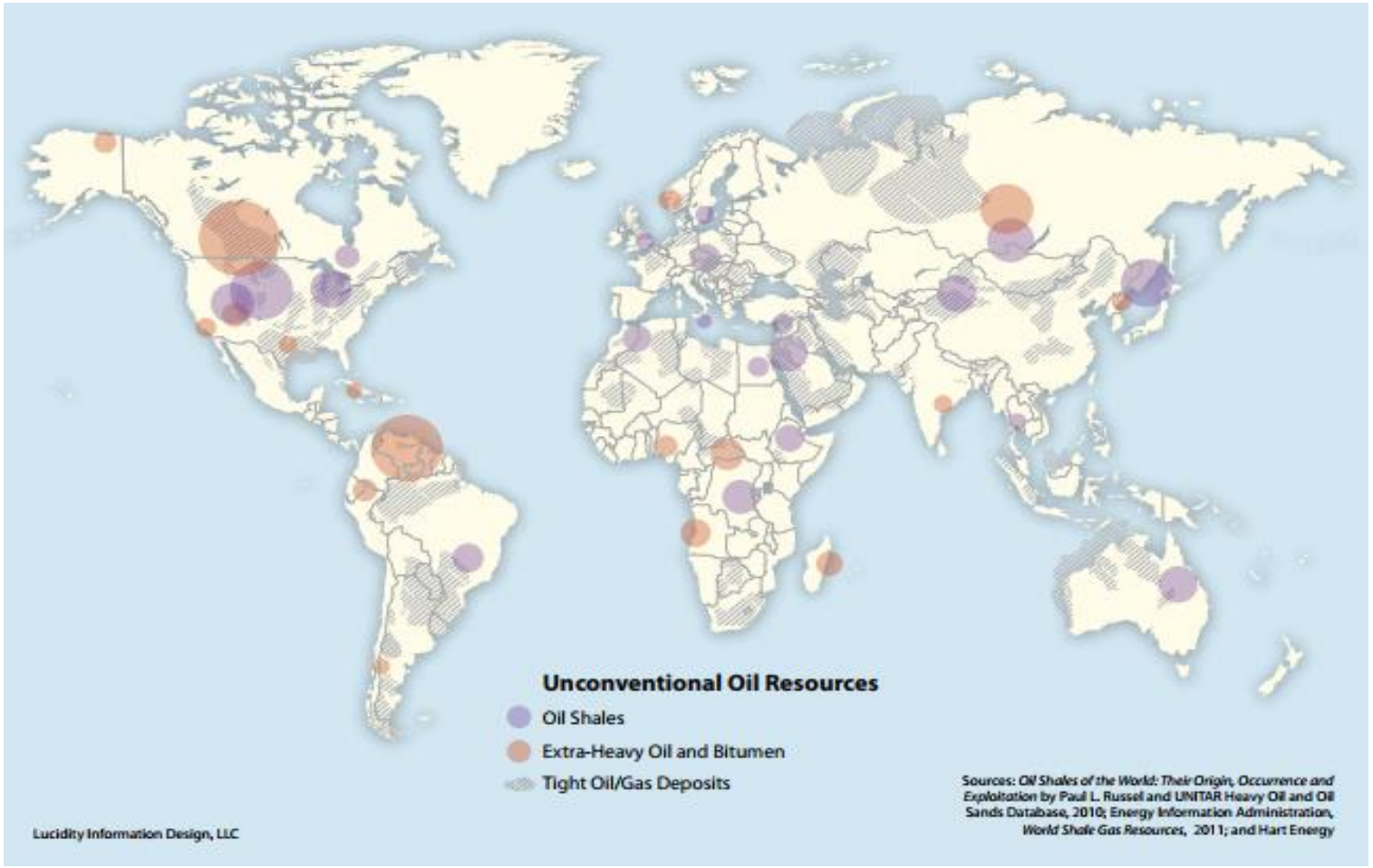
What is Unconventional EOR?



Source: carnegieendowment.org

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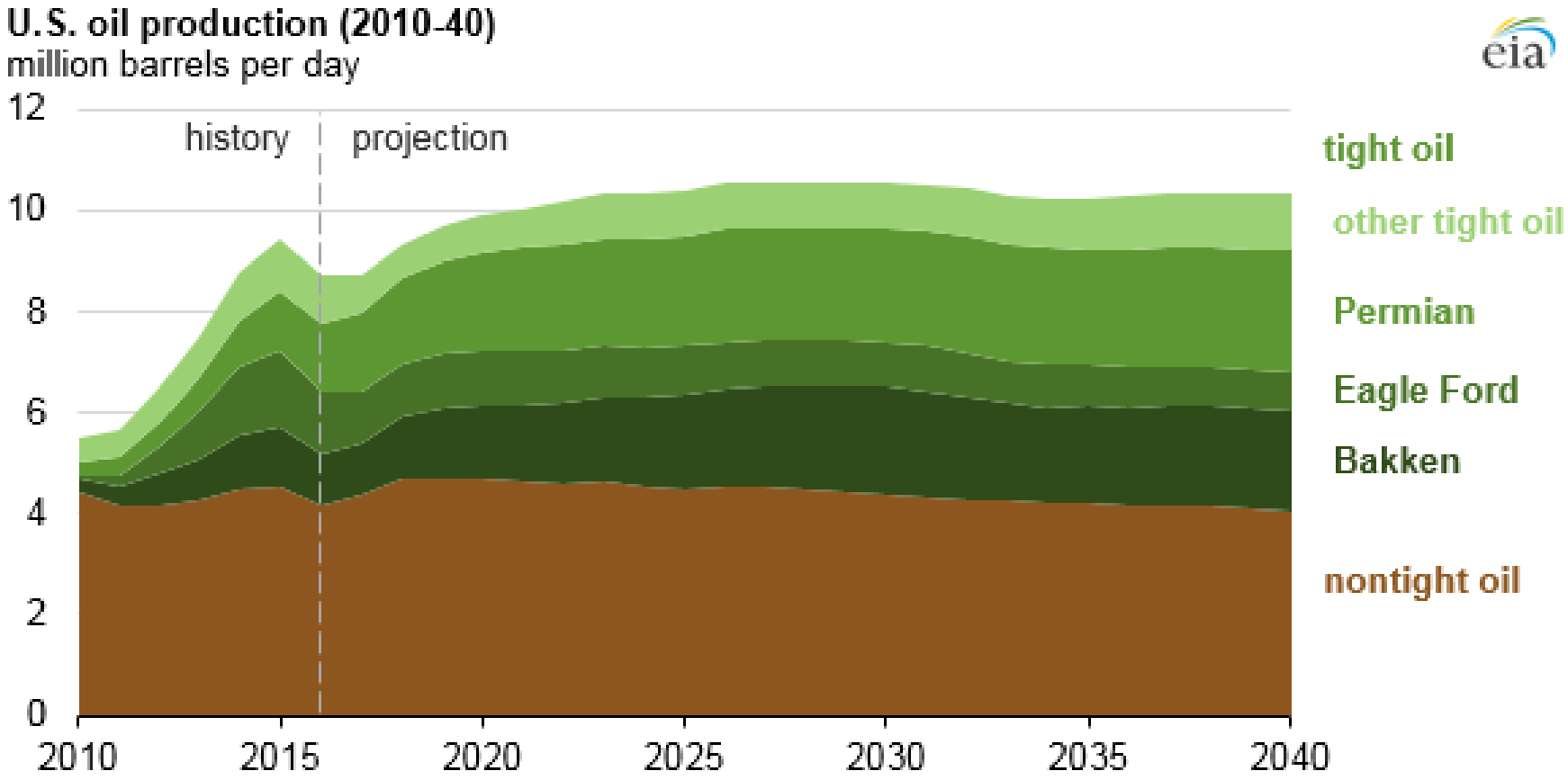
Projected U.S. Oil Production



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2017* Reference case

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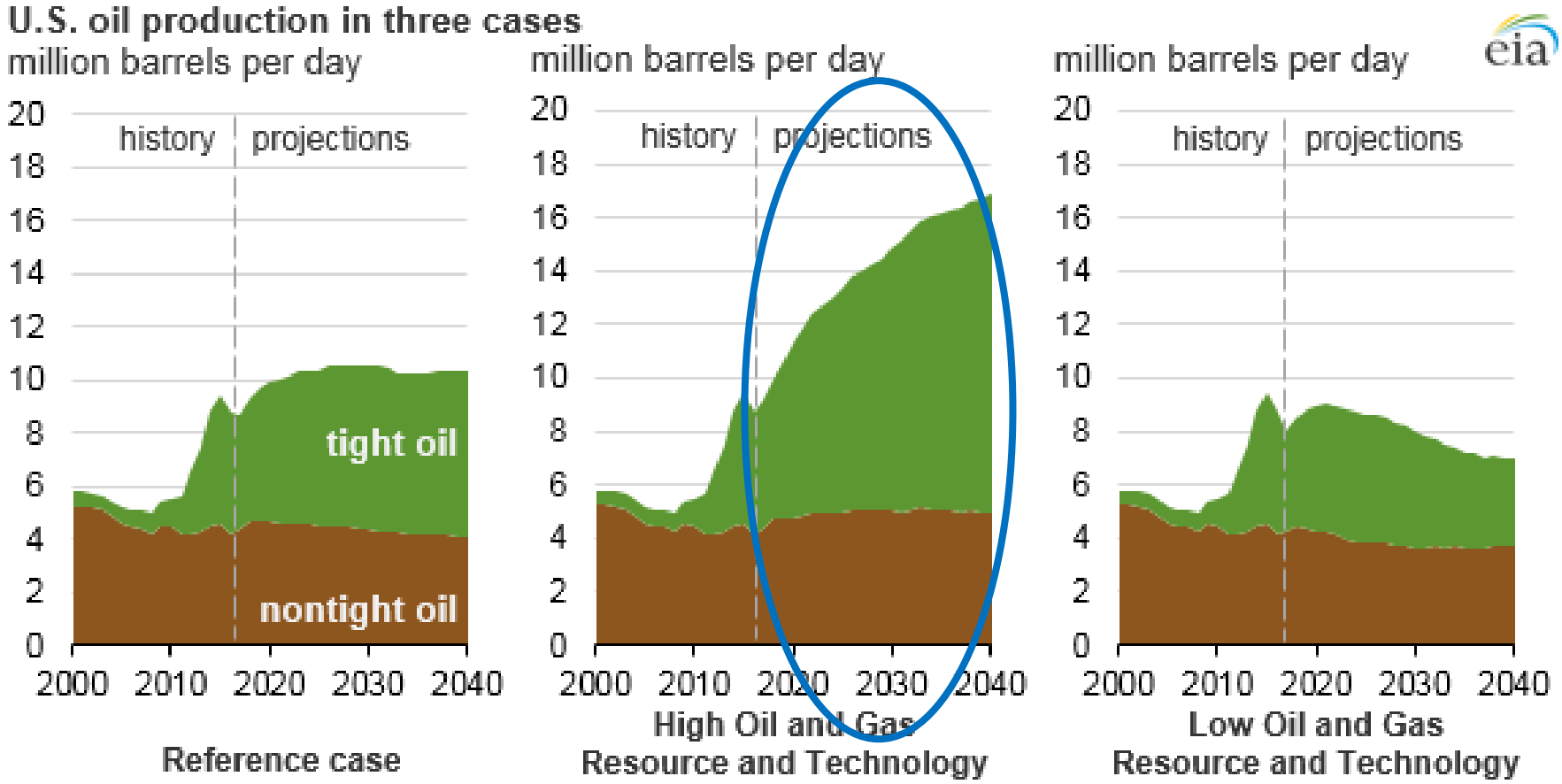
High Oil & Gas Resource & Technology



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2017*

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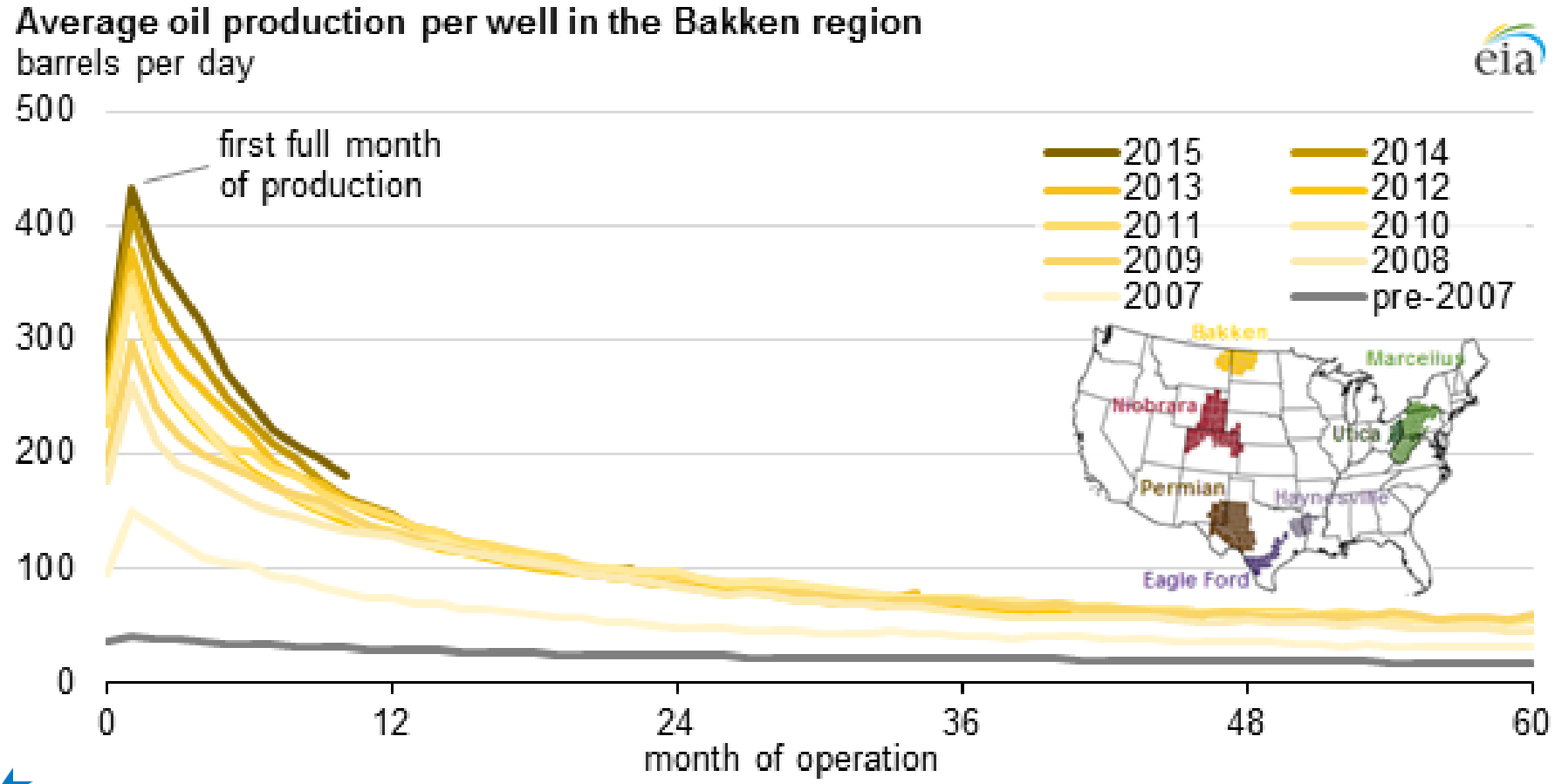
Typical Decline Curve- Bakken



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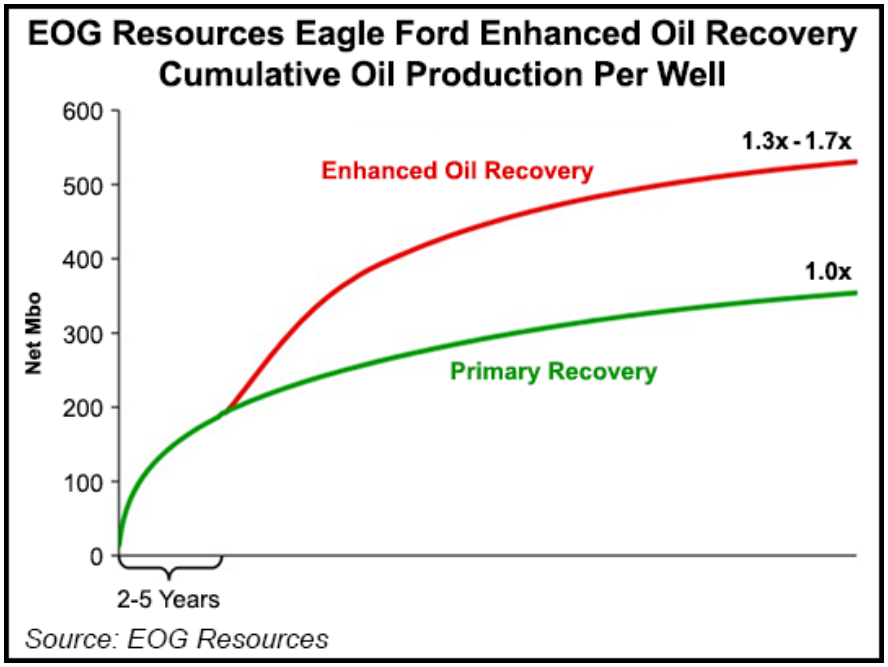
Increase EUR

- To maintain profitable production rates
- Extend the economic life of the shale plays



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Drill Less, Produce More

- Refrac
- Recompletion
- Enhanced Oil Recovery (EOR)
  - Carbon dioxide (CO_2)
  - Miscible Gas
  - Waterflood
  - Chemical EOR
  - Thermal EOR

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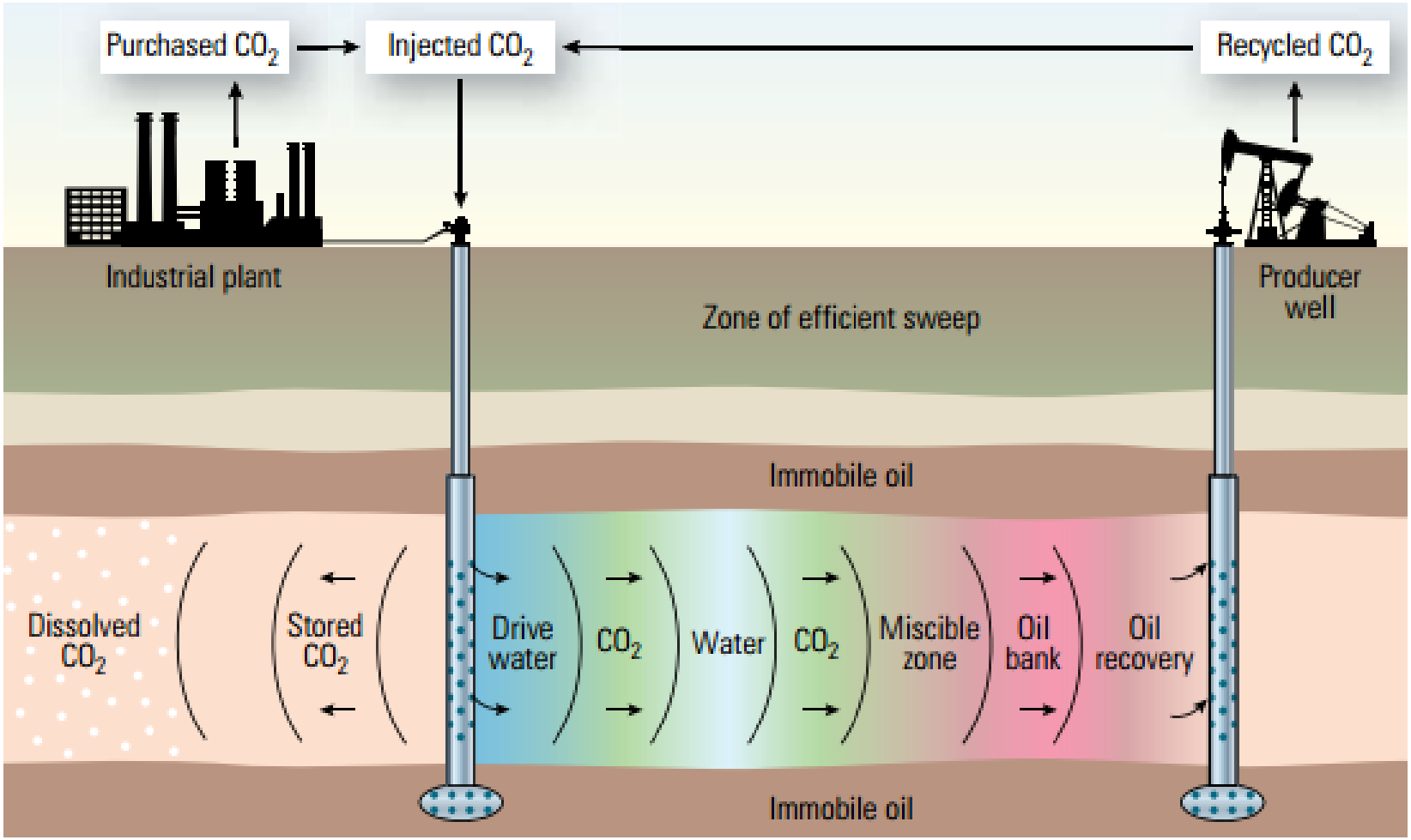
Conventional Displacement



Source: www.netl.doe.gov

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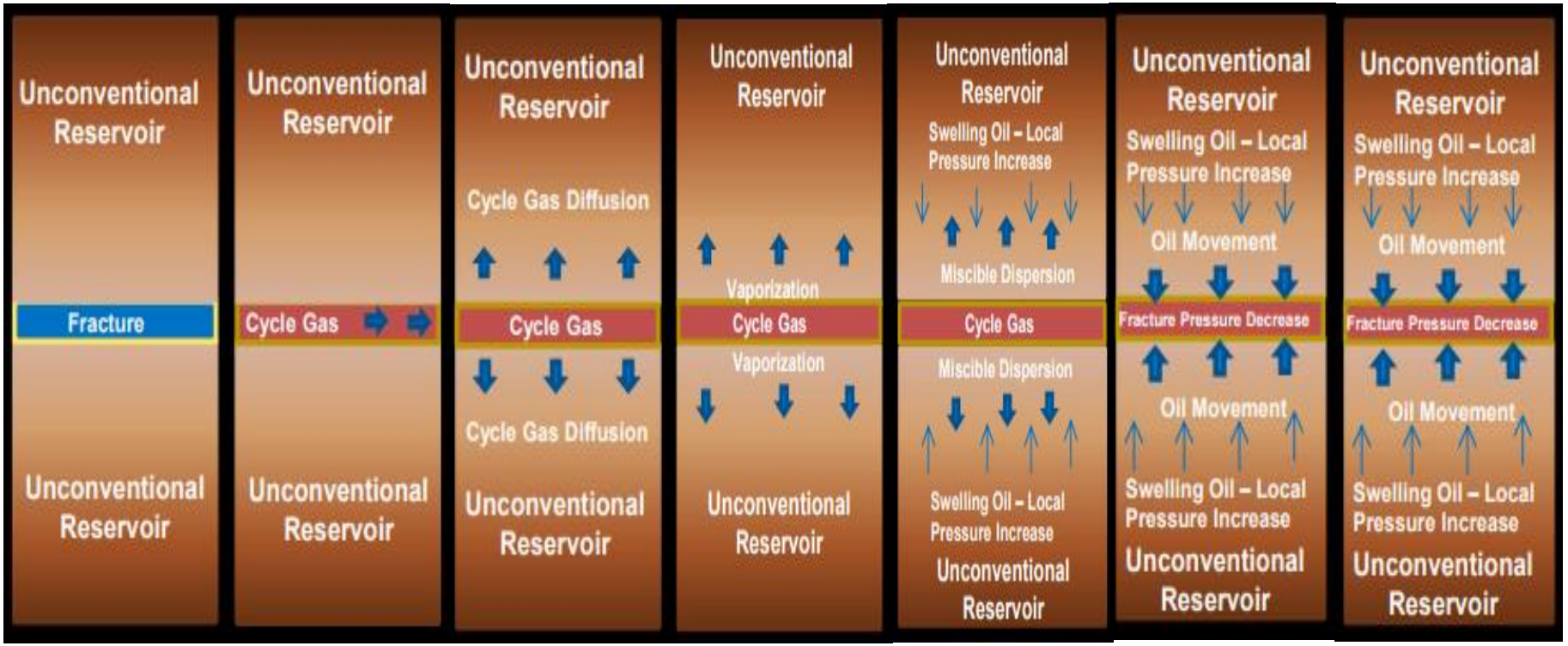
Proposed Recovery Mechanism



Source: SPE 167200

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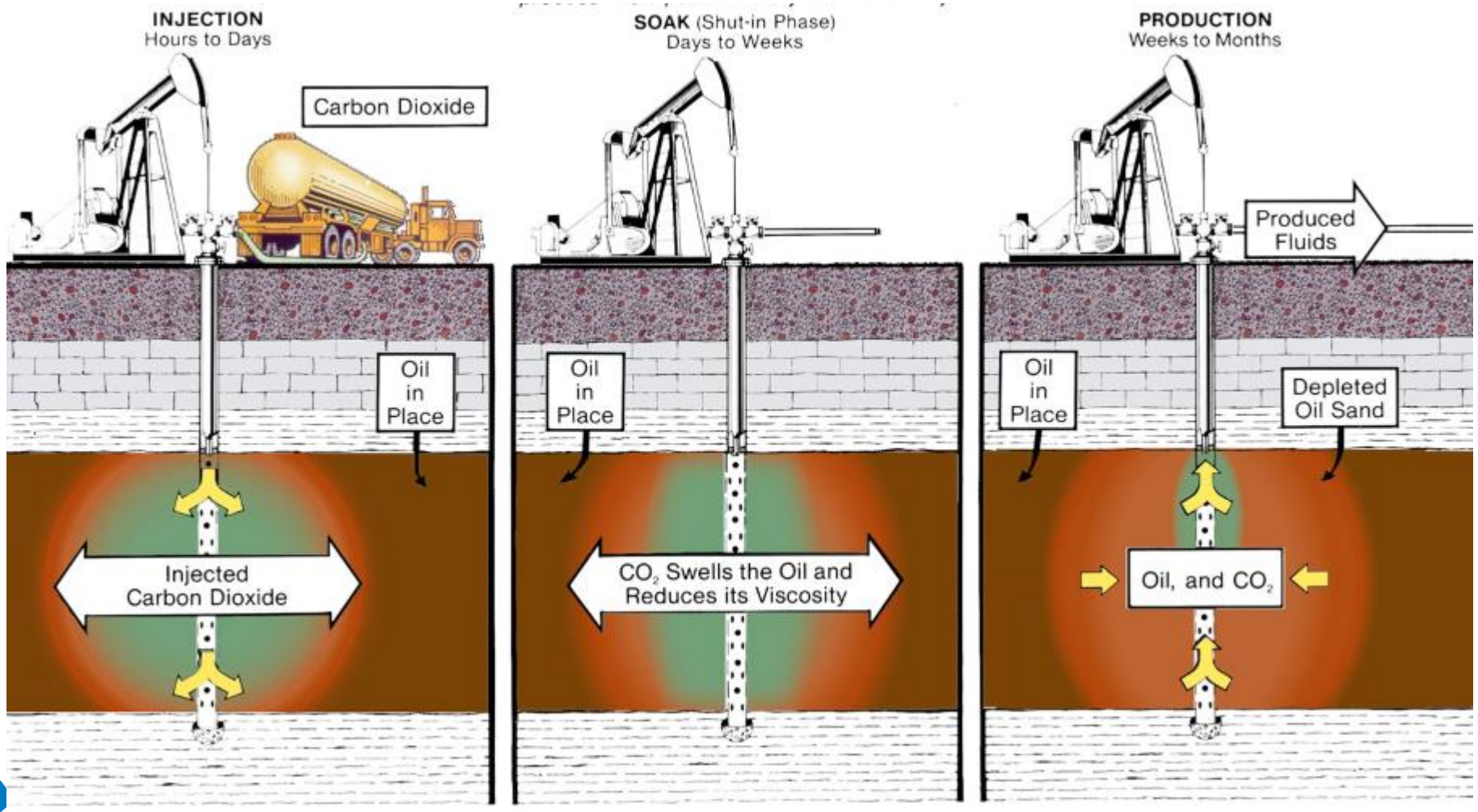
Cyclic Gas Injection (Huff and Puff)



Source: www.netl.doe.gov

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Challenges

- Success depends on access to oil in the matrix
- Hydraulically fractured
- Containment
- Ultra low matrix permeability
- Injection Fluid Selection
- Injection Mechanism

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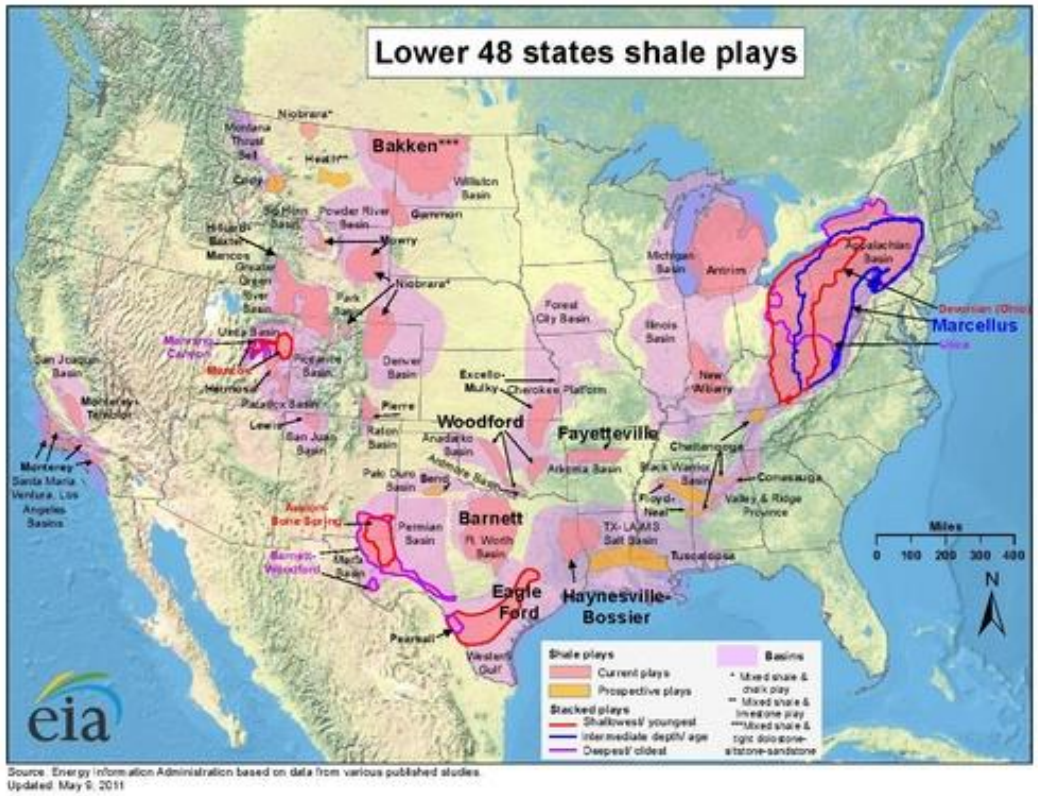
Challenges

- Reservoir
- Formation
- Surface Facilities



Source: Energy Information Administration based on data from various published studies
Updated: May 9, 2011

Source: EIA

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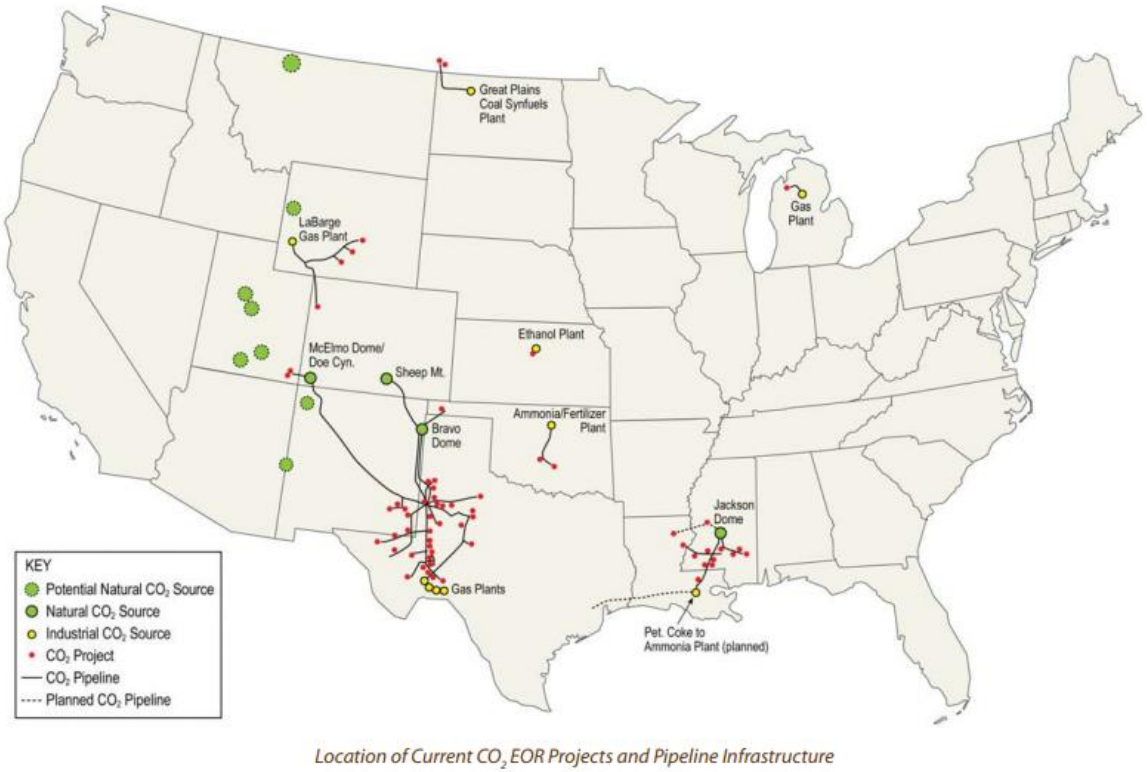
Challenges

- Reservoir
- Formation
- Surface Facilities



Location of Current CO_2 EOR Projects and Pipeline Infrastructure

Source: www.netl.doe.gov

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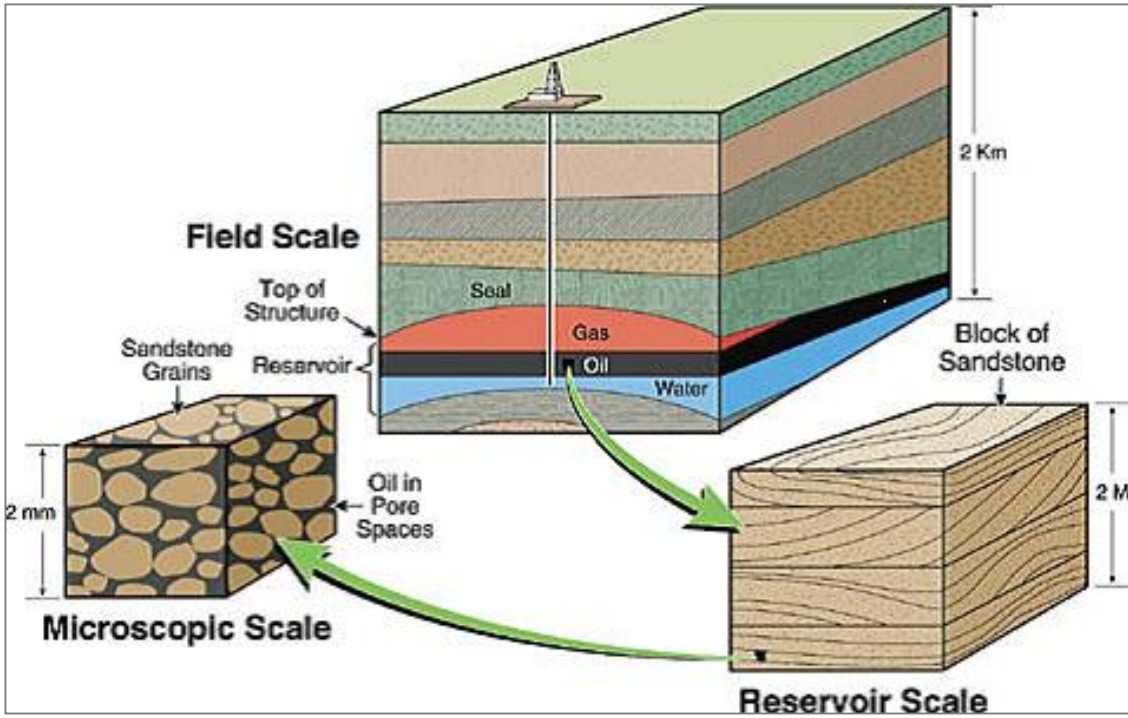
R&D Efforts

- Lab Evaluation
- Reservoir Simulation
- Field Pilots
- **Optimize**



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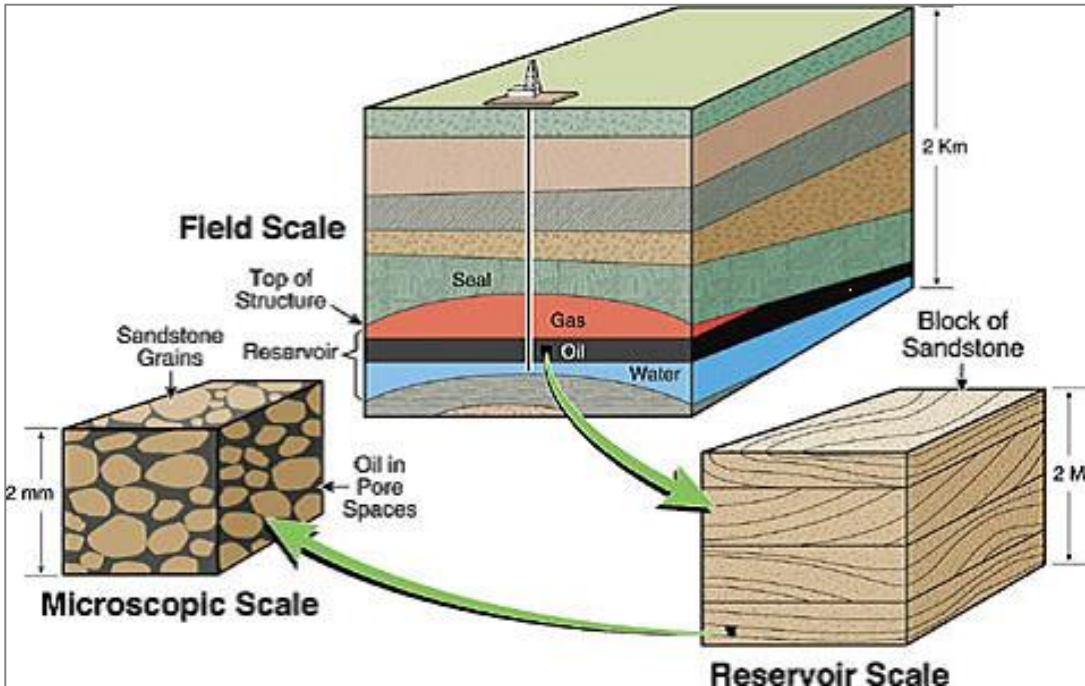
R&D Efforts

- Universities
- Service Companies
- Oil & Gas Companies
- Joint-Industry Partnerships (JIP)



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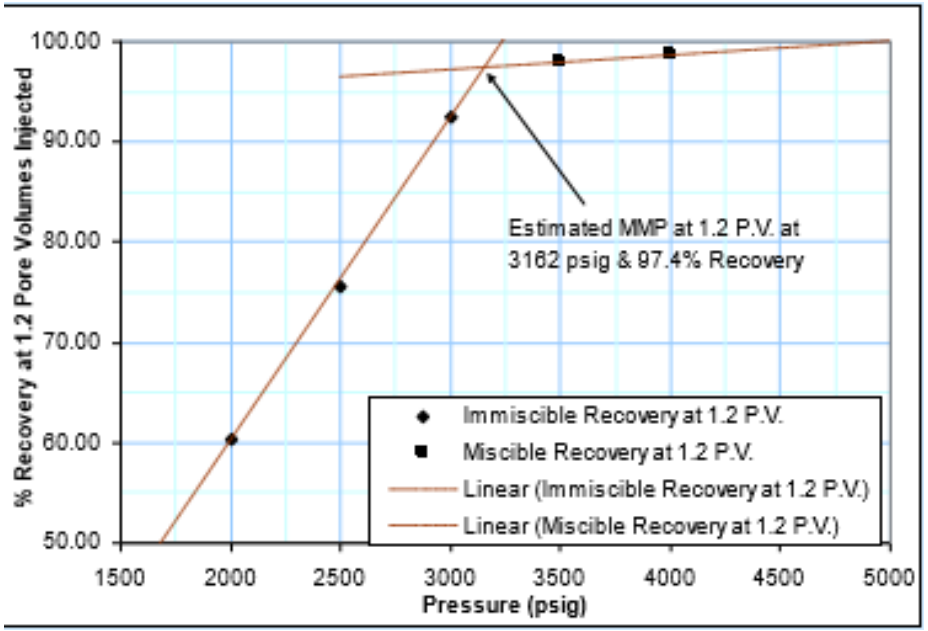
Laboratory Evaluation

- Fluids
  - Fluid Properties
  - Minimum Miscibility Pressure (MMP)
  - Minimum Miscibility Enrichment (MME)



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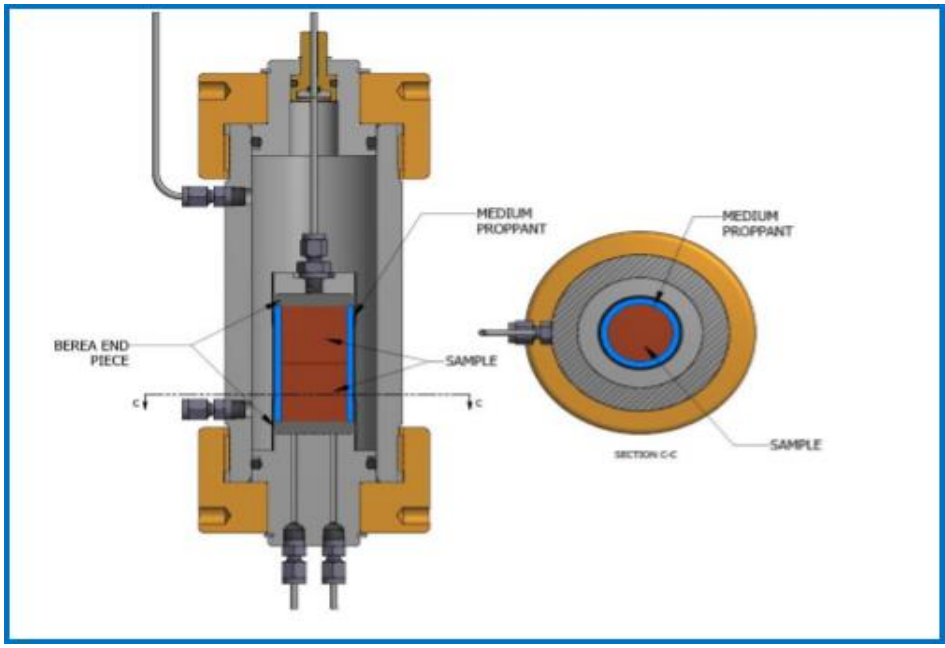
Laboratory Evaluation

- Rocks
  - Phase behavior in nanopores
  - Simulate Huff and Puff Process
- Produced Fluid Analysis



Source: SPE 169022

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Primary Completion Diagnostics

- Maximum Effective Lateral Length
- Maximize Fracture Complexity
- Interwell Communication
- Optimal Spacing
  - Well
  - Stage
  - Cluster

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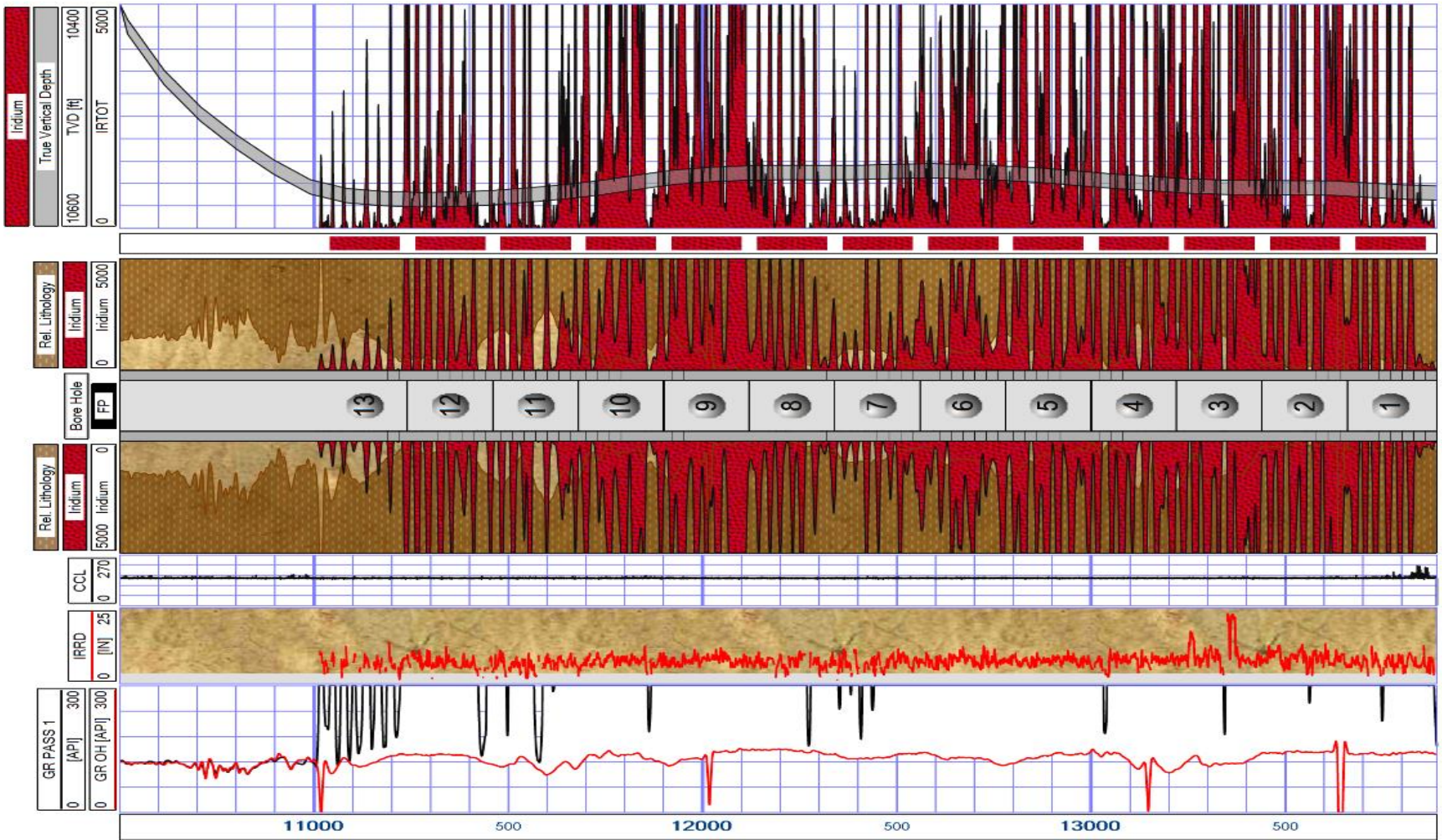
Field Pilots- Increase the chances of success

- Effective Primary Completion



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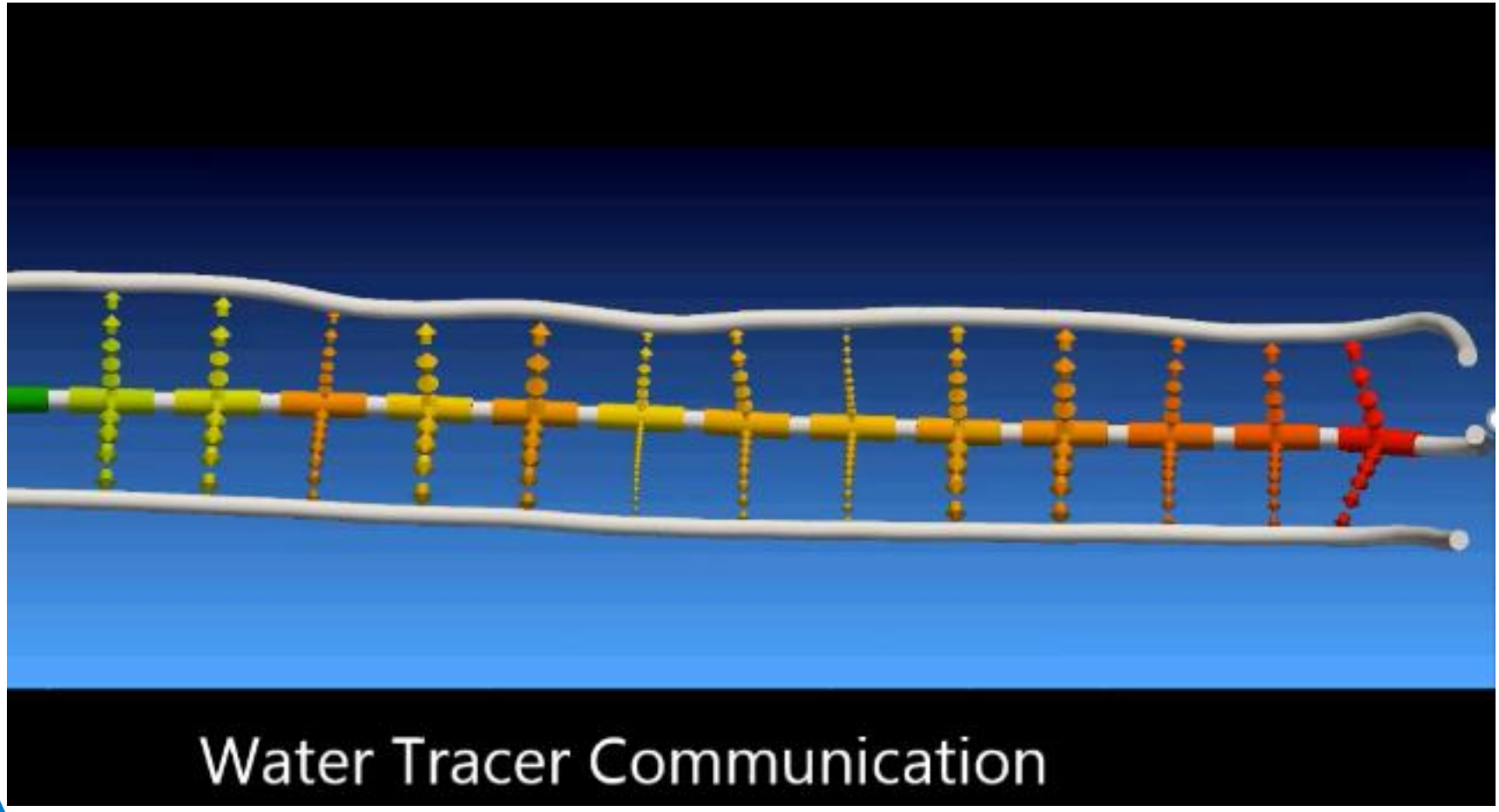
Study Primary Completions

- Inter-well Frac Communication



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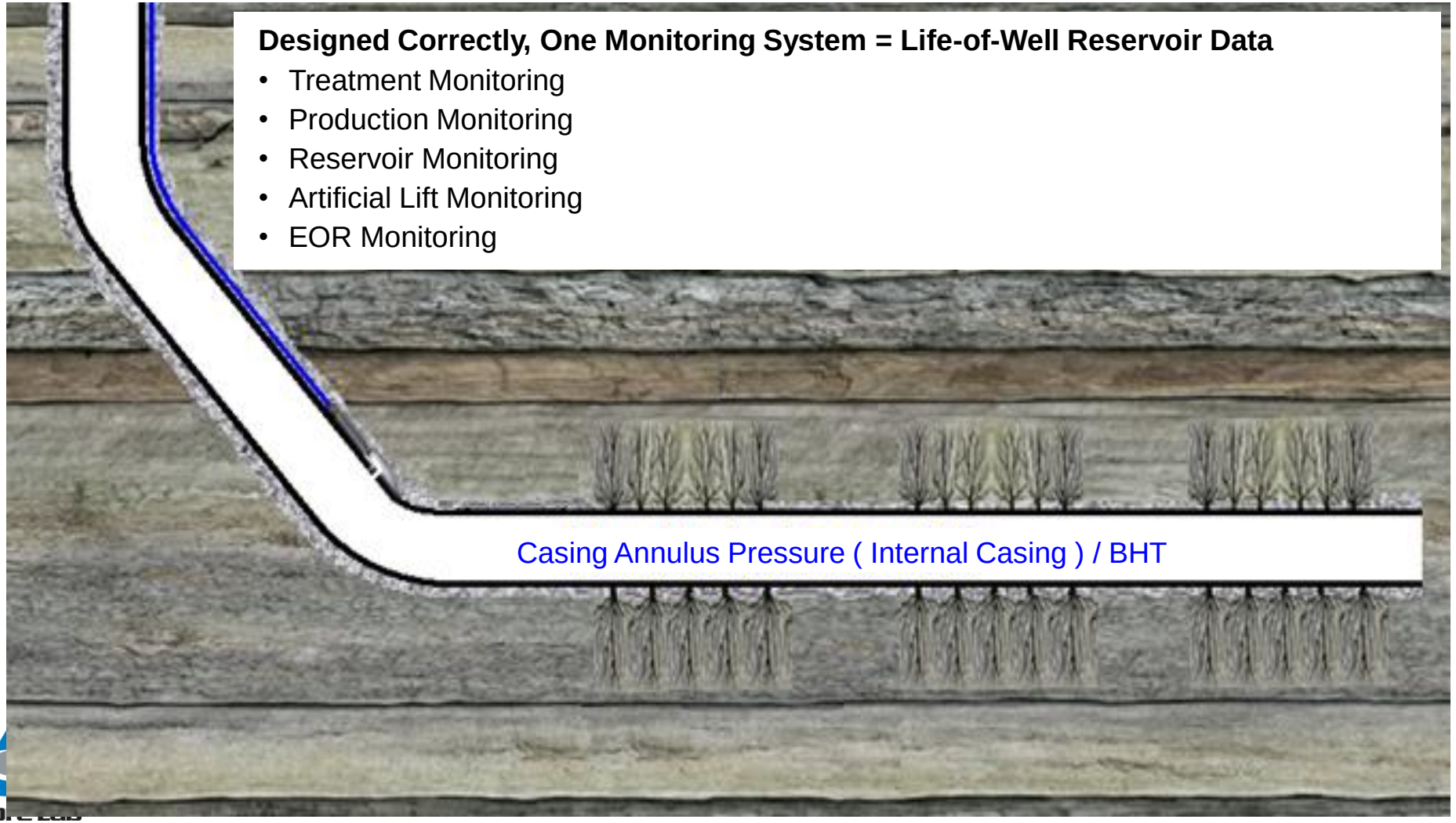
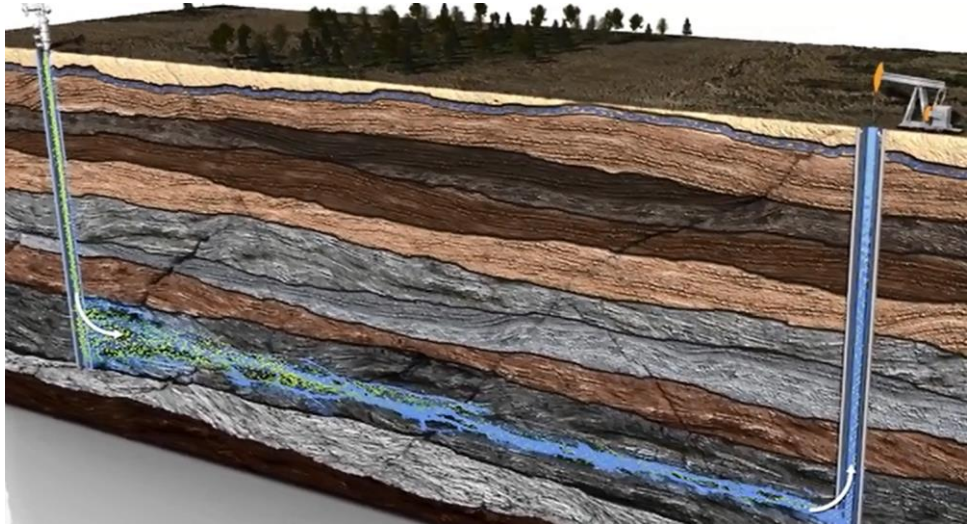
Pressure/ Temperature Gauges



Conventional IOR/EOR Diagnostics

- Early Breakthrough
- Swept Pore Volume
- Poor Sweep Efficiency
- Compare Injection Fluids' Performance
- Evaluate Conformance Control Treatments



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Unconventional EOR Diagnostics

- Containment
- Early Breakthrough
- Changes in fluid movement with each injection cycle
- Chemical Additives Evaluation
- Conformance Control Treatment Evaluation

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Fluid Tracers

- Gas Tracers
  - Used extensively in miscible gas flood, CO_2 WAG flood
  - Samples collected in pressurized canisters

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Fluid Tracers

- Oil Tracers
  - Understand oil movement in the reservoir responding the gas injection
  - Study oil tracer data along with gas tracer data

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Cyclic Gas Injection Tracer Diagnostics

- Gas tracers employed to monitor the miscible gas injection
- Oil tracers to monitor oil mobilization
- Unique tracers utilized in each injection cycle
- Compare tracer response with each injection cycle
- **When to trace?**

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Sampling

- High frequency sampling at early time
- Gas Chromatography- Mass Spectrometry (GC-MS)
- Laterals in the same zone
- Wells in zones above and below
- Offset vertical wells

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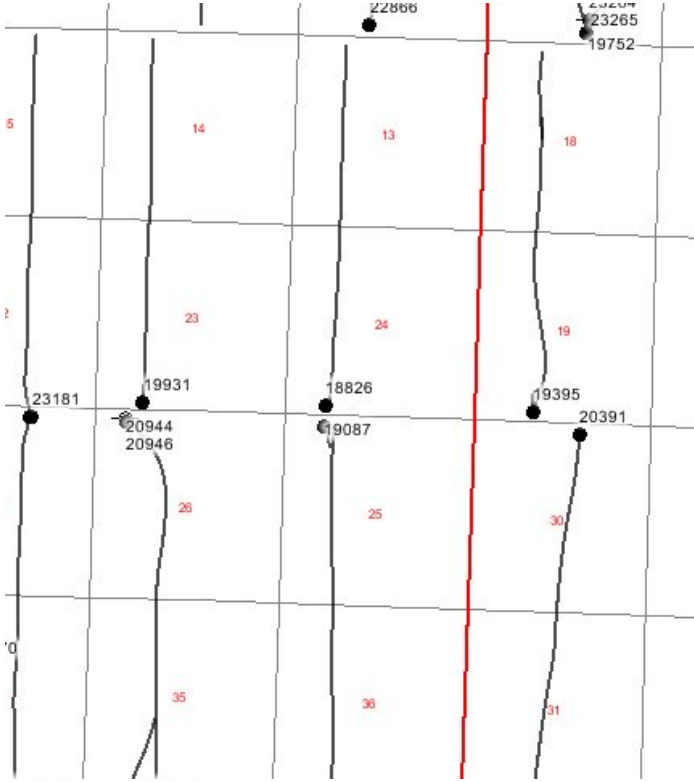
Reservoir Diagnostics

- Containment
  - Offset well communication monitoring
  - During injection, soaking, production phases
  - Recorded breakthrough
  - Gas tracer movement v. oil tracer movement



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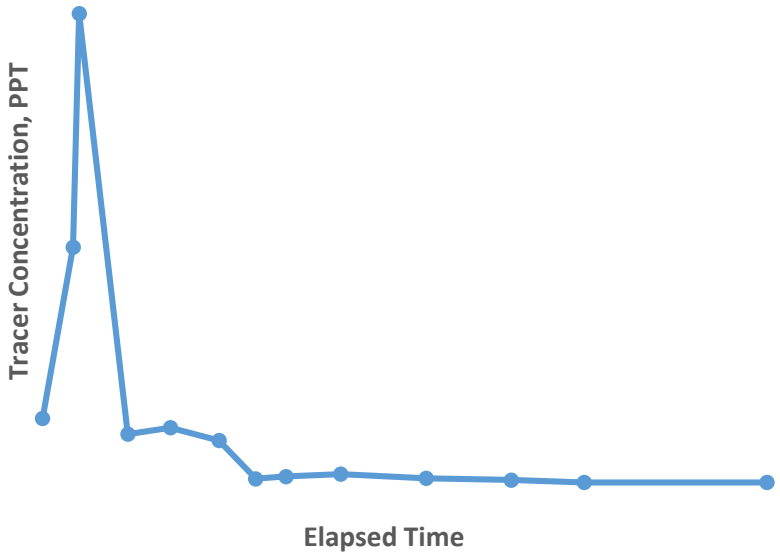
Reservoir Diagnostics

- Oil Mobilization
- Compare fluid movement in reservoir with each injection cycle and operational changes
- Fluid compositional analysis



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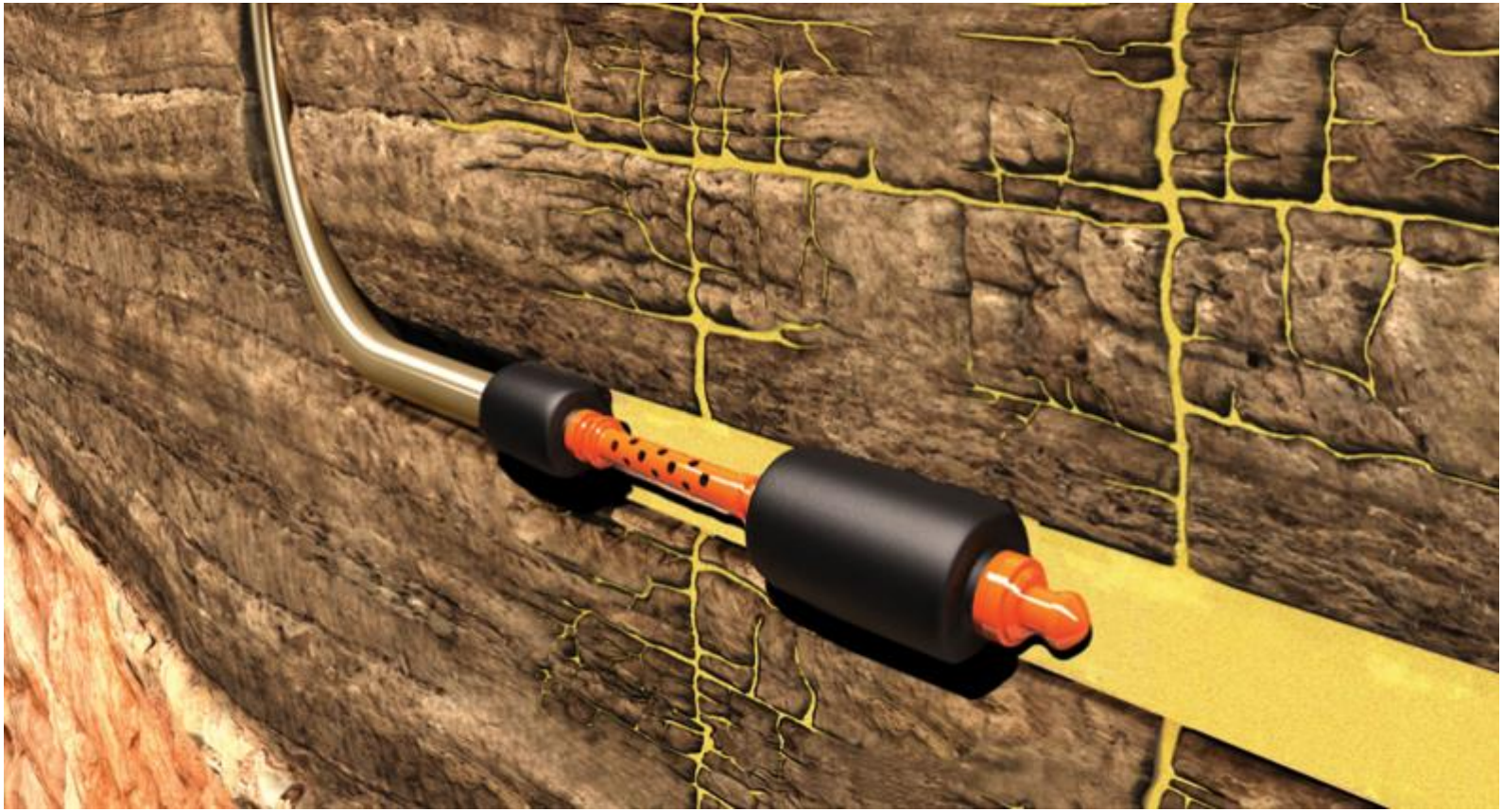
Is the heel taking most of the injection fluid?

Place tracer in individual segment before flooding



Source: TAM International

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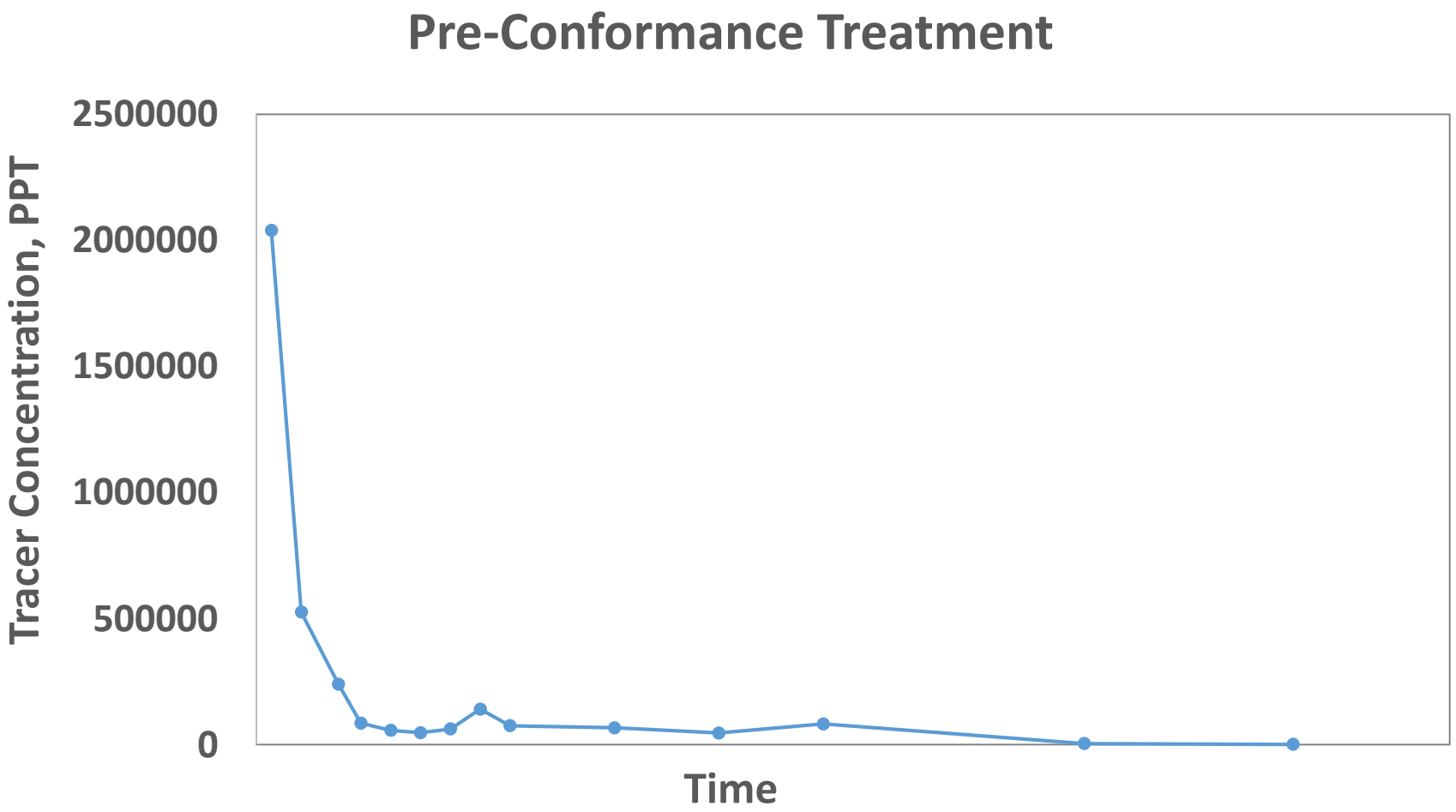
Conformance Treatment Success



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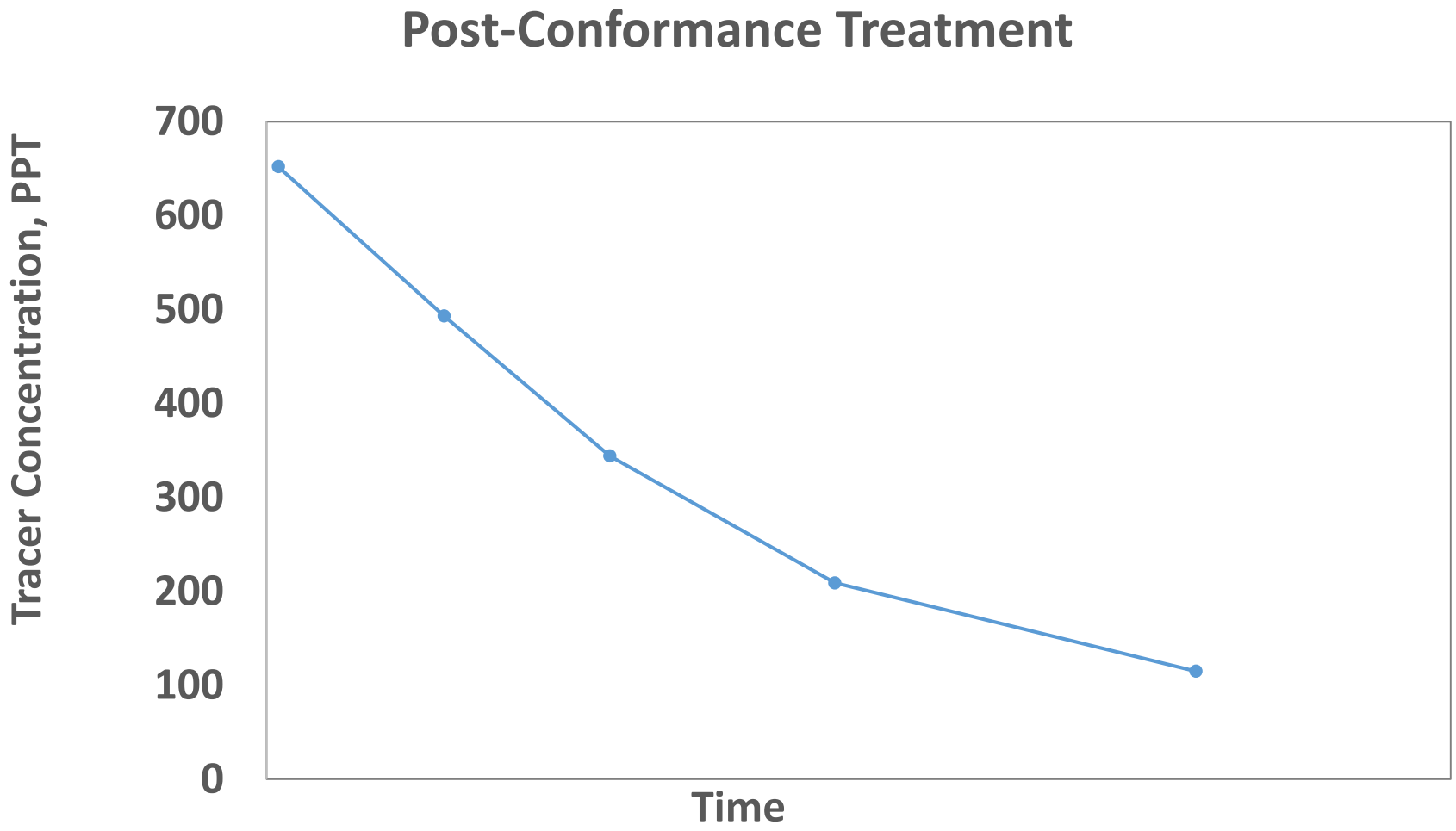

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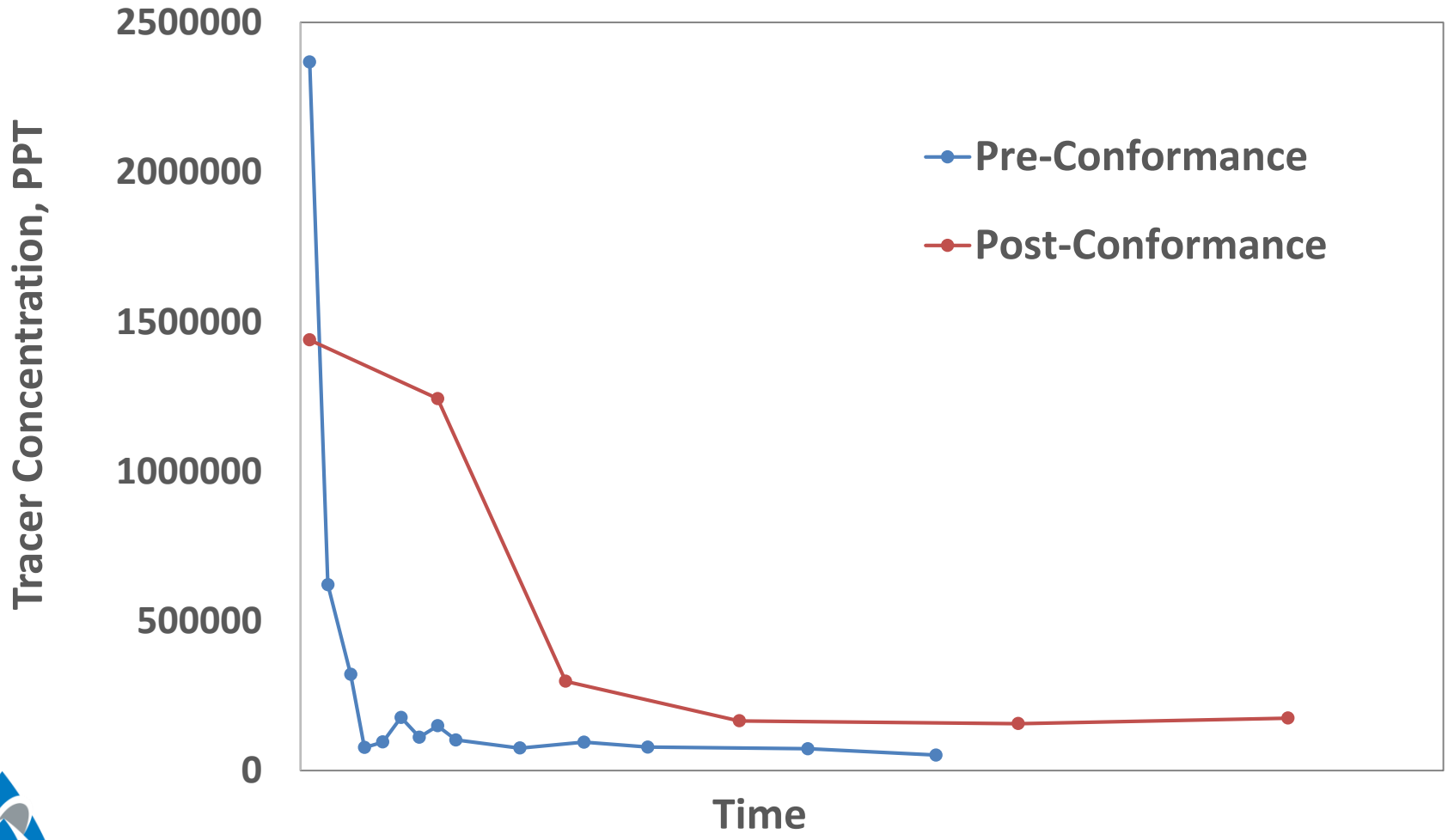
Conformance Treatment



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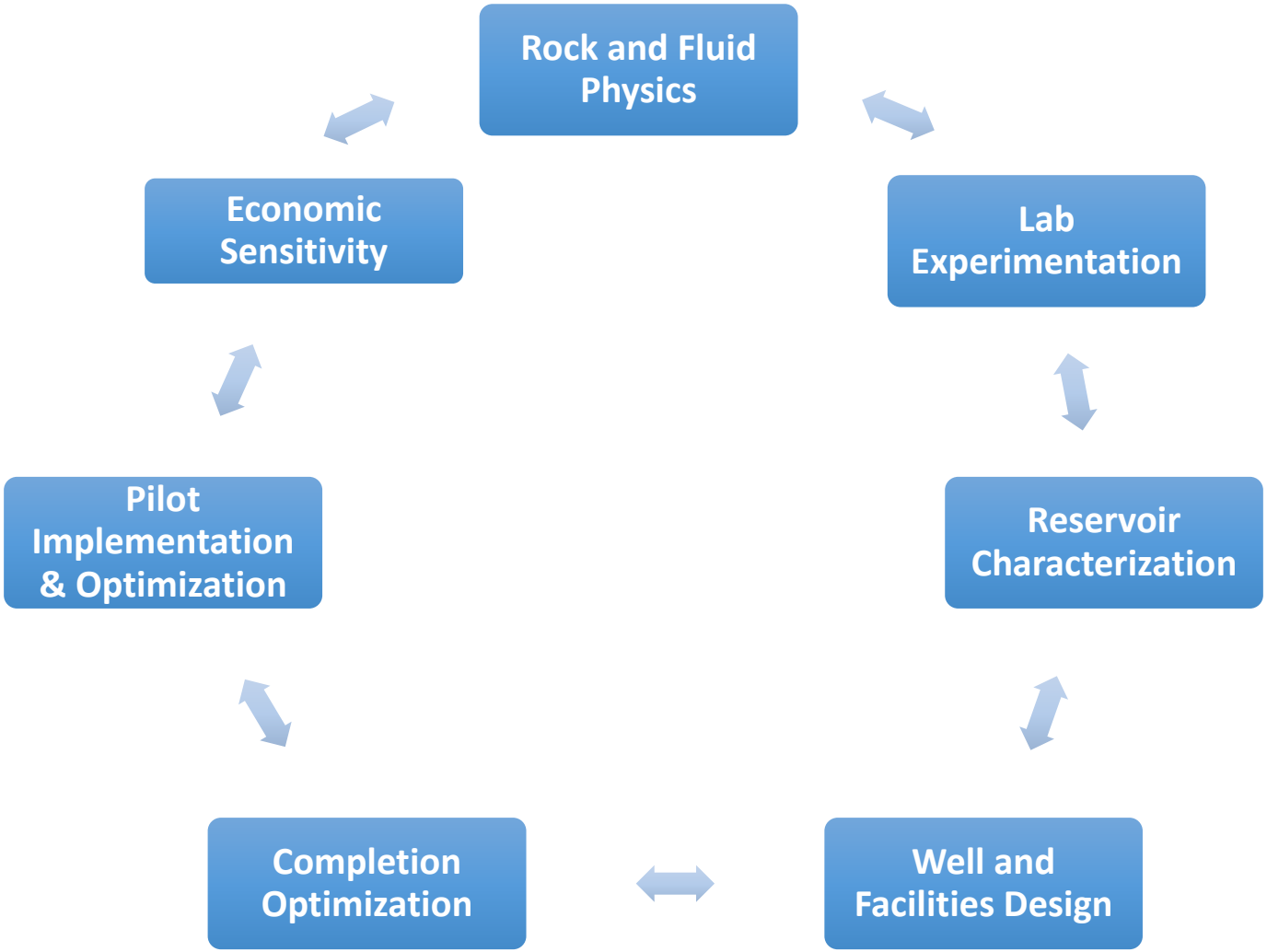
OPTIMIZE



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Thank You

Westside Study Group (SPE-GCS)

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Questions and Discussion