
N484: Reservoir Management for Unconventional Oil and Gas Resources

Instructor(s): Yucel Akkutlu

Format and Duration

Classroom - 4 Days

Virtual - 8 Sessions

Summary

This course familiarizes practicing subsurface professionals with unconventional oil and gas resources as reservoirs, covering evaluation and development aspects. Emphasis is on tight gas/oil formations and organic-rich source rocks, especially shale. It offers in-depth discussions on fluid storage, phase change, and transport for reservoir evaluation and development. Hydrocarbon in-place calculations are included, with new pore-scale considerations and a method to assess the reservoir's liquid potential. Laboratory techniques for characterizing unconventional formations are discussed. The course helps engineers understand transient flow regimes in horizontal wells with hydraulic fractures and analyze production data using analytical and simulation techniques. Field case studies illustrate tight gas and shale oil/gas reservoir development, including economic and environmental evaluation of horizontal wells with multi-stage fracturing.

Business Impact: Application of the learnings of this course will empower participants to better explain the **unconventional reservoir physics** and **improve their business performance by developing more accurate reservoir models**.

Learning Outcomes

Participants will learn to:

1. Assess, characterize and classify unconventional resources.
2. Recognize the impact of organic matter maturation and hydrocarbon generation on the resource assessment.
3. Assess oil and gas storage mechanisms for unconventional reservoirs.
4. Assess the transport mechanisms in unconventional reservoirs.
5. Design pressure transient (fall off) tests for wells in unconventional reservoirs.
6. Develop a shale gas/oil apparent permeability model for simulation using petrophysical data.
7. Perform rate transient analysis for unconventional wells and predict total fracture surface area contributing to production.
8. Evaluate the relative accuracies of unconventional reserve estimates.
9. Evaluate production rate decline characteristics of unconventional wells.
10. Formulate a field development plan for an unconventional resource.
11. Categorize similarities and differences between tight gas, shale gas, and CBM.
12. Propose an integrated use of geoscience, engineering, and advanced technology in exploitation on unconventional reserves.

Training Method

This is a classroom or virtual classroom consisting of lectures with worked examples, hands-on exercises, and discussion. Presentations by participants are encouraged.



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Who Should Attend

The course is designed for mid to senior level engineers and engineering managers that have some familiarity with unconventional reservoirs.

Course Content

Part 01: Introduction

- Unconventional oil and gas resources:
 - Tight gas characteristics
 - Source rock (CBM, organic-rich shale) characteristics
- Unconventional resources in North America, their oil/gas production trends, and reserves
- What is shale and what makes shale a hydrocarbon resource?
- Resource-reservoir duality and the concept of reservoir creation

Part 02: Fundamentals

- Source rock burial, diagenesis, catagenesis, and metagenesis
- Multi-scale pore structure development in source rocks
- Multi-scale oil and gas storage mechanisms in shale
- Occurrences of hydrocarbons in organic and inorganic pore networks in source rocks
- Phase change and capillarity in nanopores
- Volumetric calculations for shale: gas, wet-gas, condensate, and oil
- Material balance calculations for CBM and shale gas wells
- Flow and other mass transport mechanisms for shale gas and oil reservoirs
- Stress-dependent shale permeability
- Stress-dependent fracture permeability models
- Flow calculations using Wasaki's permeability model for organic-rich shale
- Multi-phase flow considerations in source rocks

Part 03: Reservoir Evaluation and Characterization for Resource Shale

- Reservoir sample analysis
- Special core analysis
 - Pore-size distribution, capillary pressure, relative permeability, wettability
 - Geomechanical properties
 - Organic and inorganic material characterization
- Organic matter classification: bitumen vs. kerogen
- Kerogen type and maturity
- Hydrocarbons recovery potential from kerogen



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- Integration of core-data and log-data
 - TOC estimation
 - Free and sorbed-phase fraction analysis
- Examples on shale core measurement data and analysis
- Exercise on predicting shale gas and shale oil permeability

Part 04: Drilling and Completion Techniques for Shale Formations

- Fundamentals of directional and horizontal drilling
- Considerations on rotary steerable systems (RSS)
- Designing bit weight for the vertical section, build section, and the lateral section
- Major drilling challenges in shale
- Overbalanced, underbalanced, and managed pressure drilling
- Drilling-induced transverse fractures and formation damage mechanisms
- Completion techniques
 - Cased and cemented hole completion
 - Open hole completion
- Example comparison of the Eagle Ford wells completion data

Part 05: Multi-stage Hydraulic Fracturing in Shale Wells

- Fundamentals of hydraulic fracturing operation
- Effective fracture length
- Re-fracking and re-completion considerations
- Tip screenout process
- Hydraulic fracturing using “plug and perf” and “sliding sleeve”
- Impact of fracturing fluid damage on production during flow-back
- Example simulation of the fracturing fluid invasion and flow-back
- Exercise on treatment of fracture skin

Part 06: Monitoring

- Micro-seismic monitoring of hydraulic fractures
 - Downhole monitoring
 - Surface monitoring
- Tilt meter and its applications in monitoring near well fractures
- Image logs and their application in monitoring near well fractures
- Example fractures identification using tiltmeter
- Example fractures identification using wellbore image logs

Part 07: Pre-frac Injection Test Analysis



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- Pressure fall-off (or DFIT) Test Analysis and Interpretation
 - Typical pressure transient and its signatures
 - Breakdown pressure, instantaneous shut-in pressure, fracture closure pressure
 - Analysis of the pressure fall-off data for flow capacity, leak-off type, and presence of fractures
- Example calculation of the breakdown pressure
- Example calculation of the overburden stress using Eaton's equation

Part 08: Geomechanics

- Fracture evolution in ductile and brittle formations
- Griffith's theory of brittle rock failure
- Laboratory measurements
- Stress-strain diagrams
- Popular geo-mechanical concepts for stimulation decisions
- Example decision making on vertical locations for perforations in cased-cemented hole
- Exercise on calculation of the four elastic moduli using uniaxial test data

Part 09: Transient Flow Regimes and Production Analysis

- Reservoir flow regimes and flow patterns
- Pressure evolution during transient flow
- Production rate transient signatures in flow patterns
 - Vertical wells with hydraulic fracture
 - Horizontal wells with and without hydraulic fracture
 - Horizontal well with multiple hydraulic fractures
- Production rate transient analysis (RTA) methods
 - Type-curves
 - Straight line methods
 - Flow simulation
 - Empirical methods, e.g. Arps, Duong, stretched exponential decline
- Total fracture surface area calculations using RTA with dynamic matrix permeability
- Workflow for engineering analysis of horizontal wells with hydraulic fractures
- Example type-curve analysis

Part 10: Recent Trends on Shale Oil and Gas Development

- How to deliver efficiency during surface operations, i.e., surface efficiency
- How to remove waste from operations
- How to reduce footprint
- Closed loop drilling and water conservation
- Low energy drilling
- Wellbore integrity challenges due to shale lamination and fissility



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- Hydraulic fracturing using slick water and other fluids
- High-pressure high-temperature fracturing fluids
- Re-fracking and re-completion trends
- Flow back operations
- IOR/EOR Potential for shale gas/oil wells
 - Miscible hydrocarbon gas injection
 - Carbon dioxide injection using huff and puff
 - Micro-emulsion injection during hydraulic fracturing or re-fracking
- Examples of CO₂ injection and molecular interactions using Grand Canonical Monte Carlo simulation

Part 11: Case Studies

- A tight gas field case study in Canada
- Single-well fracture interference study using Barnett data
- Single well fracture surface area calculations using rate transient analysis (RTA)
- History-matching Marcellus shale gas well
 - Impact of the number of transverse fractures on future recovery
- History-matching Eagle Ford shale gas well
- History-matching Bakken shale oil well
- A shale gas well completion optimization
 - Procedure of calculating hydraulic fracture economics: NPV, IRR, DROI
 - Number of fracture stages/clusters
 - Transverse fracture spacing
 - Fracture propped-length