Distinguished Lecturer Program

Primary funding is provided by

The SPE Foundation through member donations and a contribution from Offshore Europe

The Society is grateful to those companies that allow their professionals to serve as lecturers

Additional support provided by AIME

Distinguished Lecturer Program

SPE International

Beyond Volumetrics: Unconventional Petrophysics for Efficient Resource Appraisal

David R. Spain

BP Upstream Technology Group

bp

Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl

Outline

- Conventional vs Unconventional Petrophysics
- Beyond Volumetrics
- Workflow Elements (Case Study)
- Putting it All Together
- Uncertainties
- Conclusions

Conventional vs. Unconventional Petrophysics

What is the volume of hydrocarbon in place?

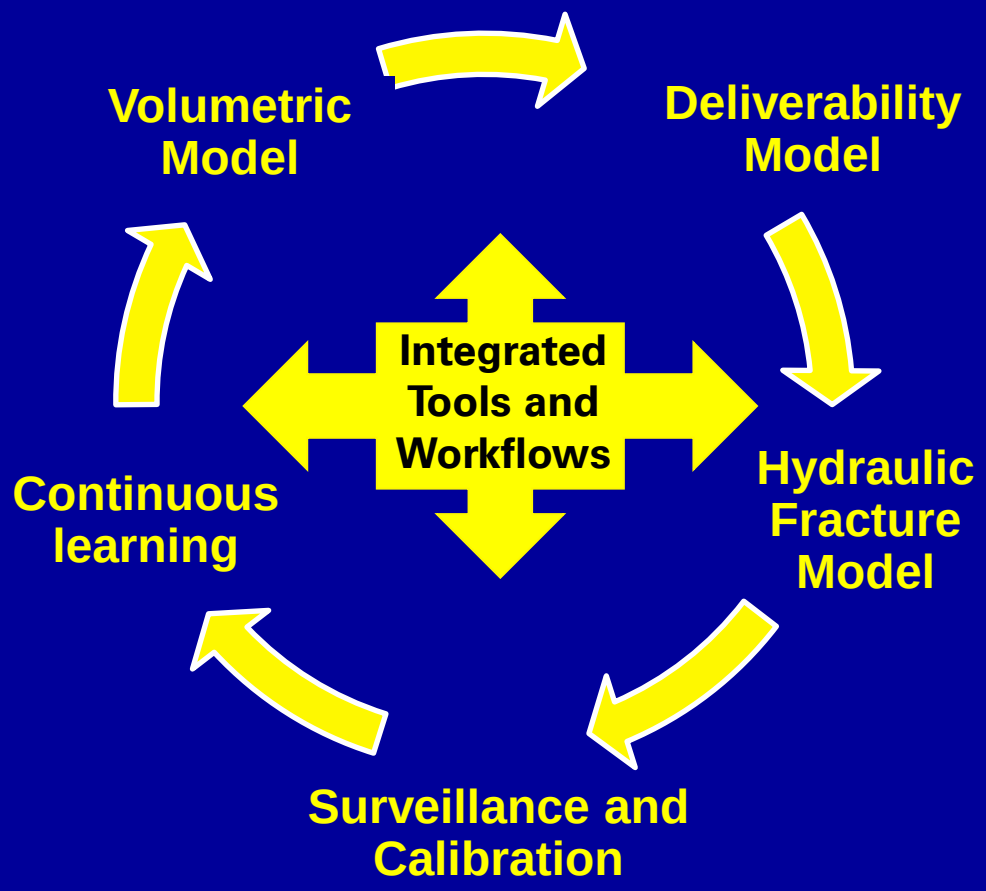
- Focused on thickness, porosity, saturation, static characterization
- Storage capacity is key

How much hydrocarbon can we economically extract?

- Focused on initial rate and decline - Low recovery factors
- Flow capacity and “fraccability” is key

Beyond Volumetrics

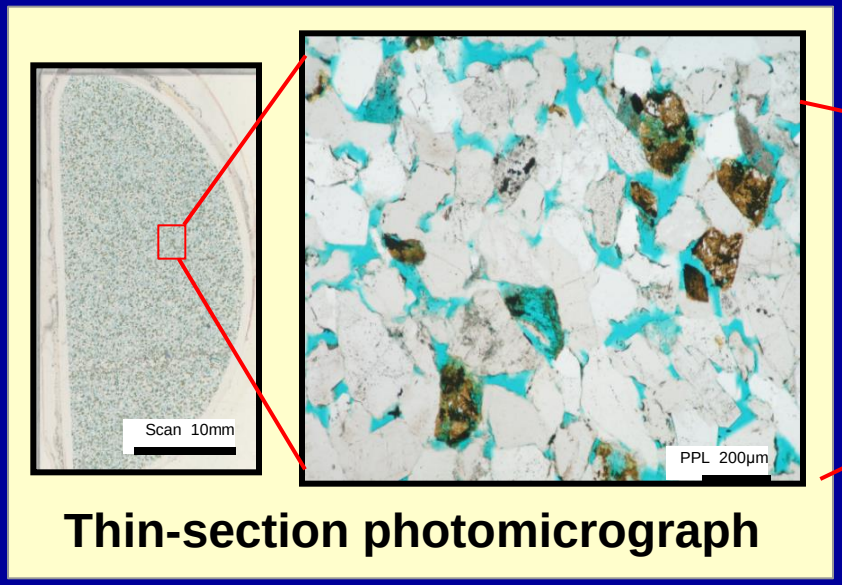
- New mindsets and cross-discipline expertise
- Tightly integrated, calibrated workflows
- Continuous learning and improvement

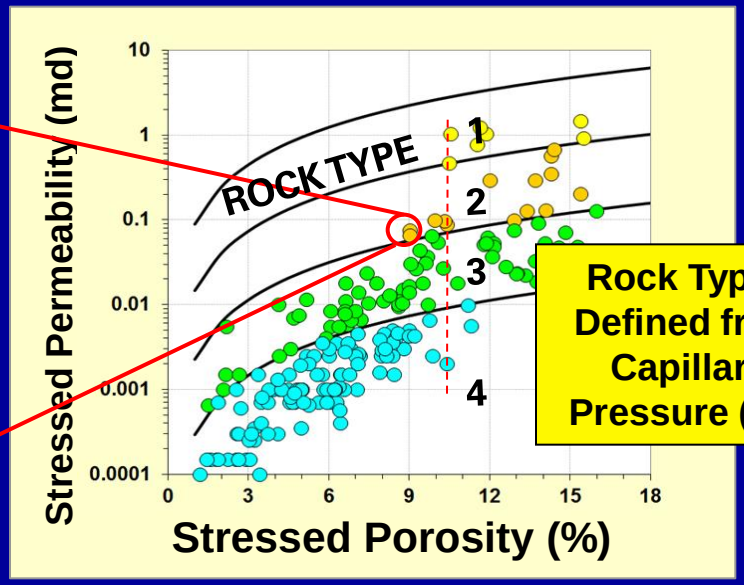


Resource appraisal must go "Beyond Volumetrics"

Workflow Elements - Fundamentals

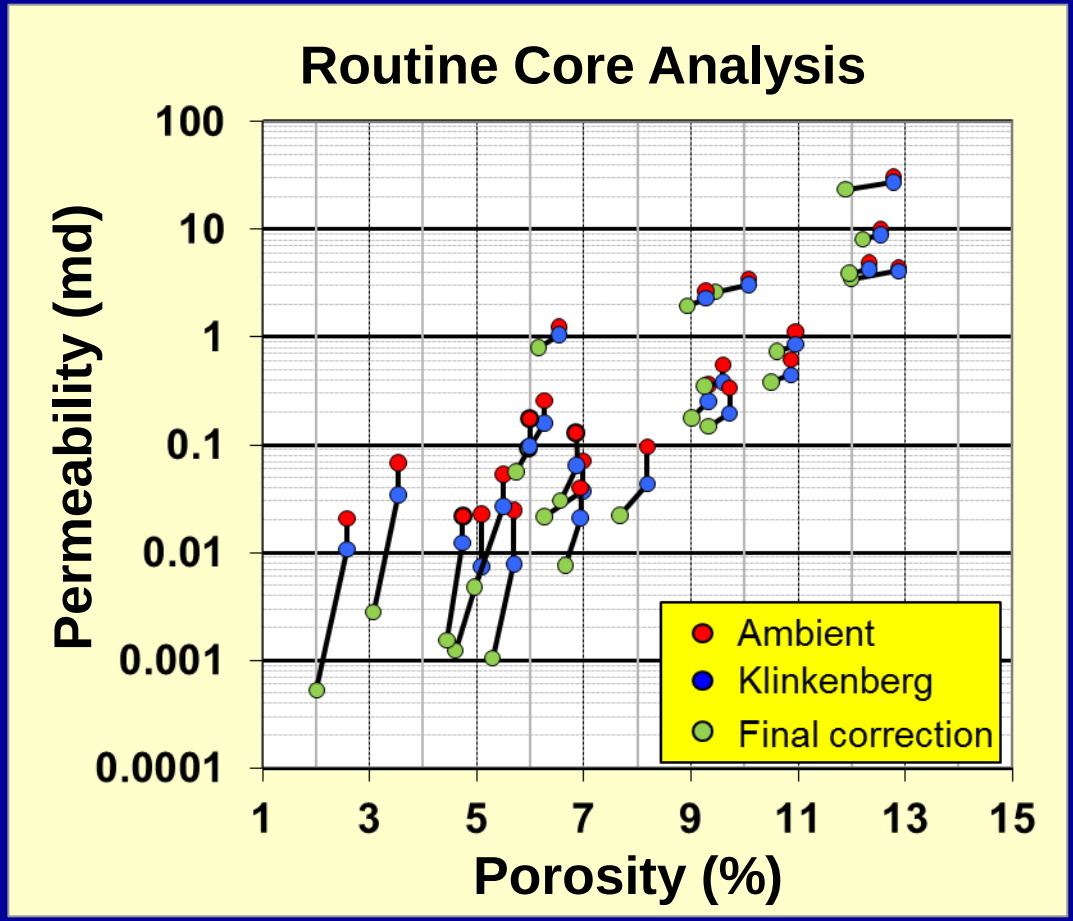
- Geological description
  - Deposition, geological history (stress and saturation)
- Petrophysical characterization using core data
  - Focus on flow capacity, not just storage capacity





Stress Corrections

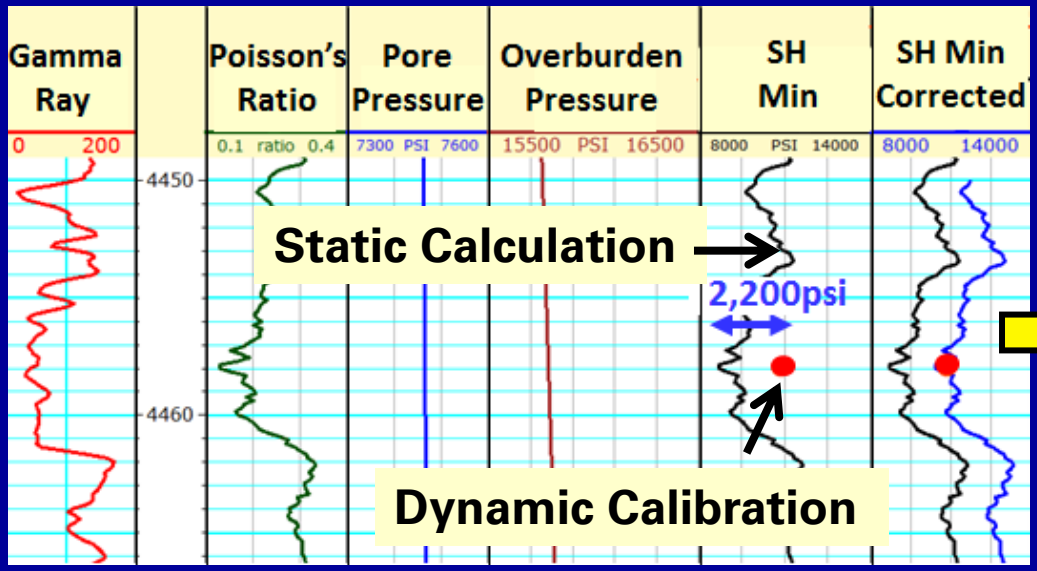
- Klinkenberg Corrections - for laboratory gas pressure measurement artifacts
- Poro-elastic Corrections – to correct benchtop test conditions for *in-situ* stresses

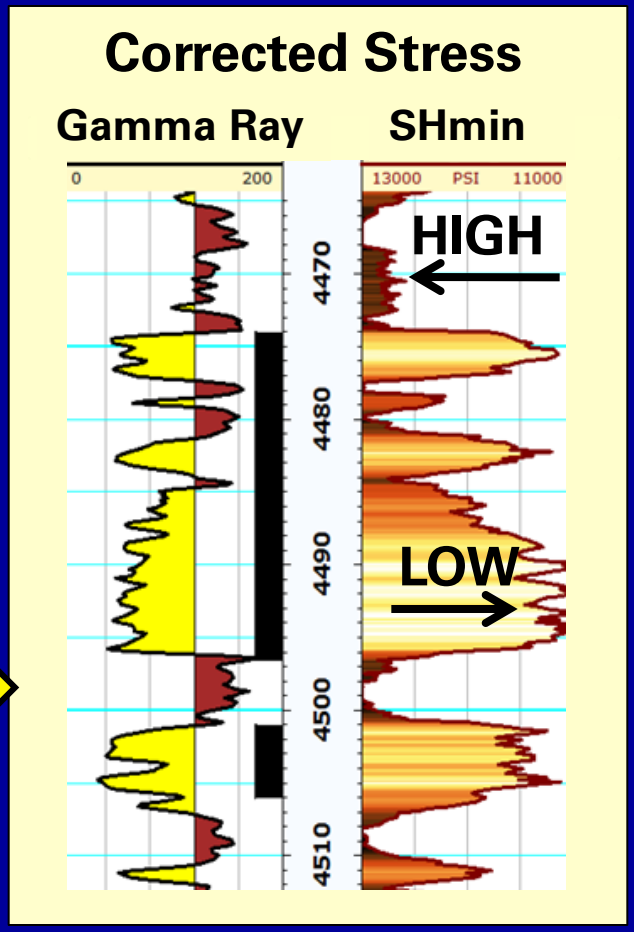


Unconventional Reservoirs are very stress-sensitive !

Stress Profiles

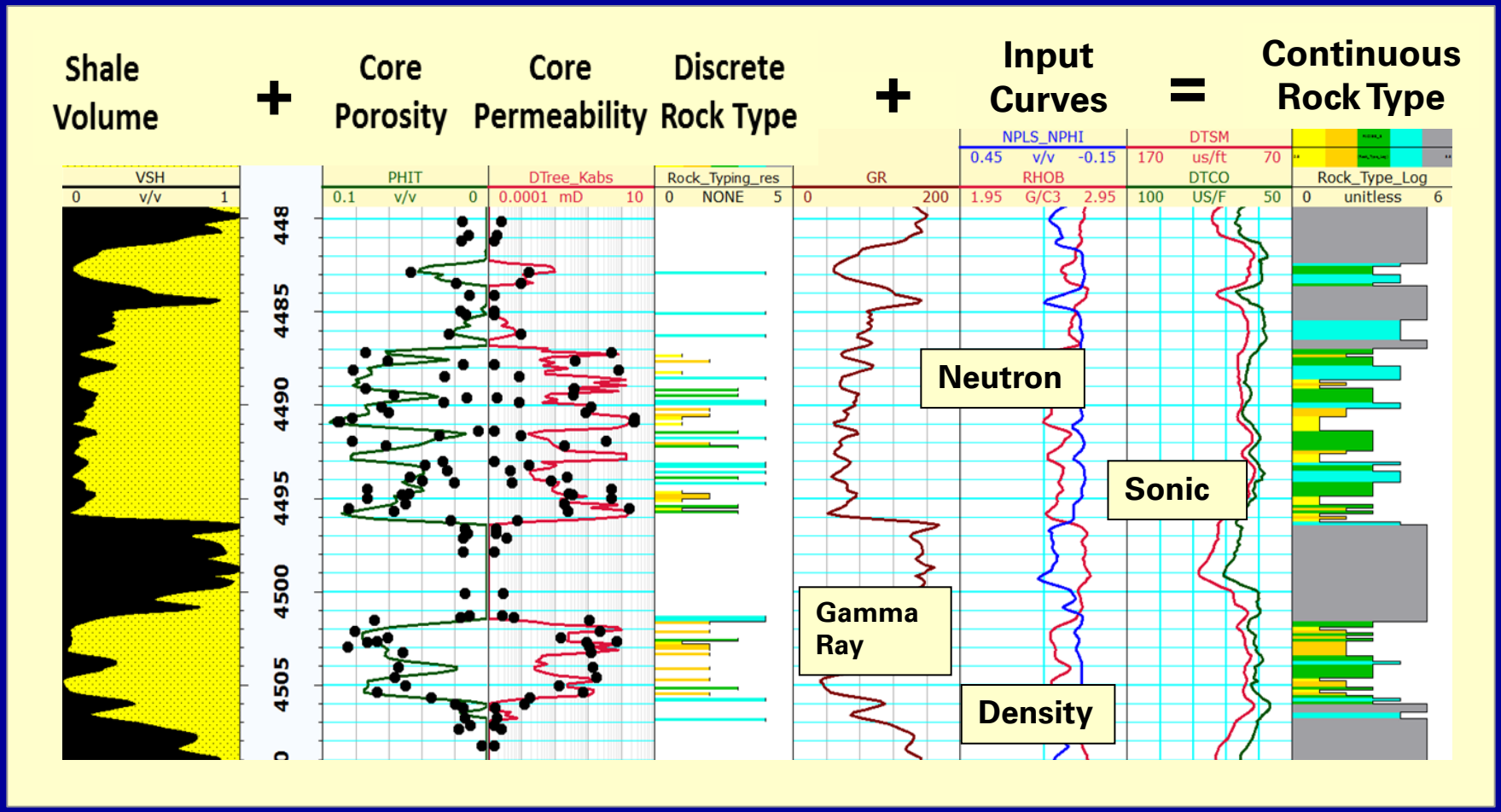
- Horizontal Stress governs hydraulic fracture orientation
- Vertical Stress profiles govern fracture height growth





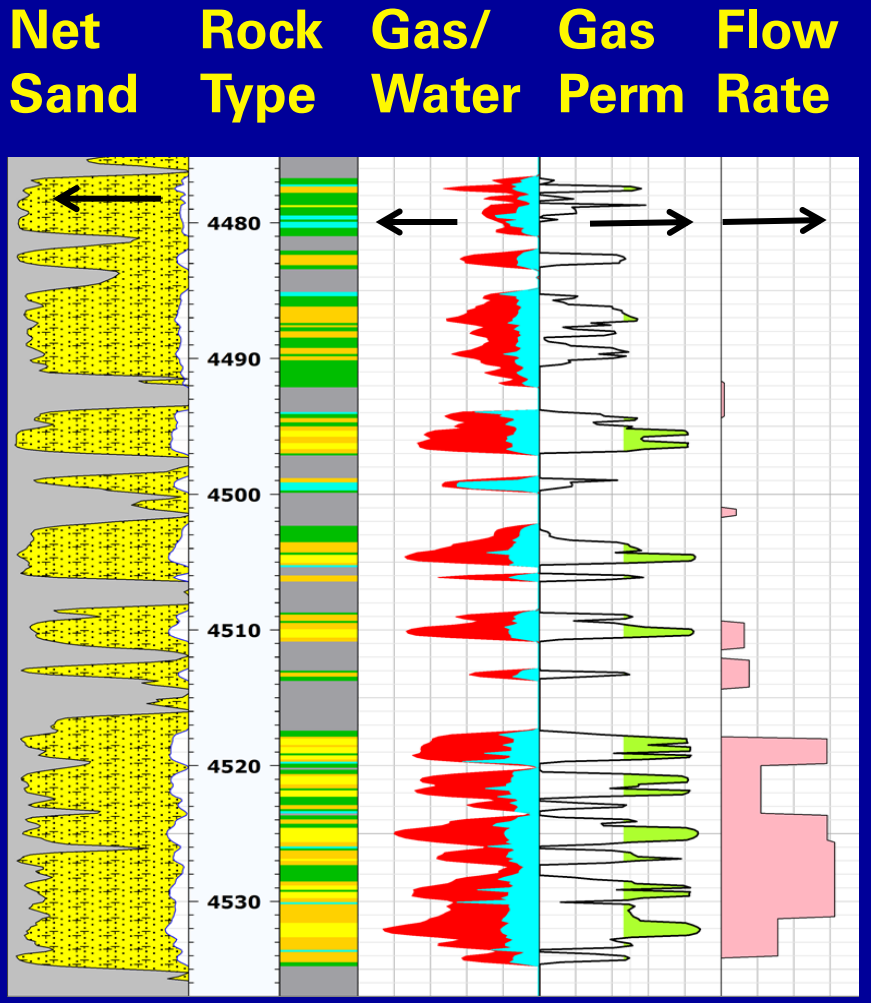
Continuous Rock Type Curves

- Develop Rock Type models using modern well log evaluation methods



Deliverability Profiles

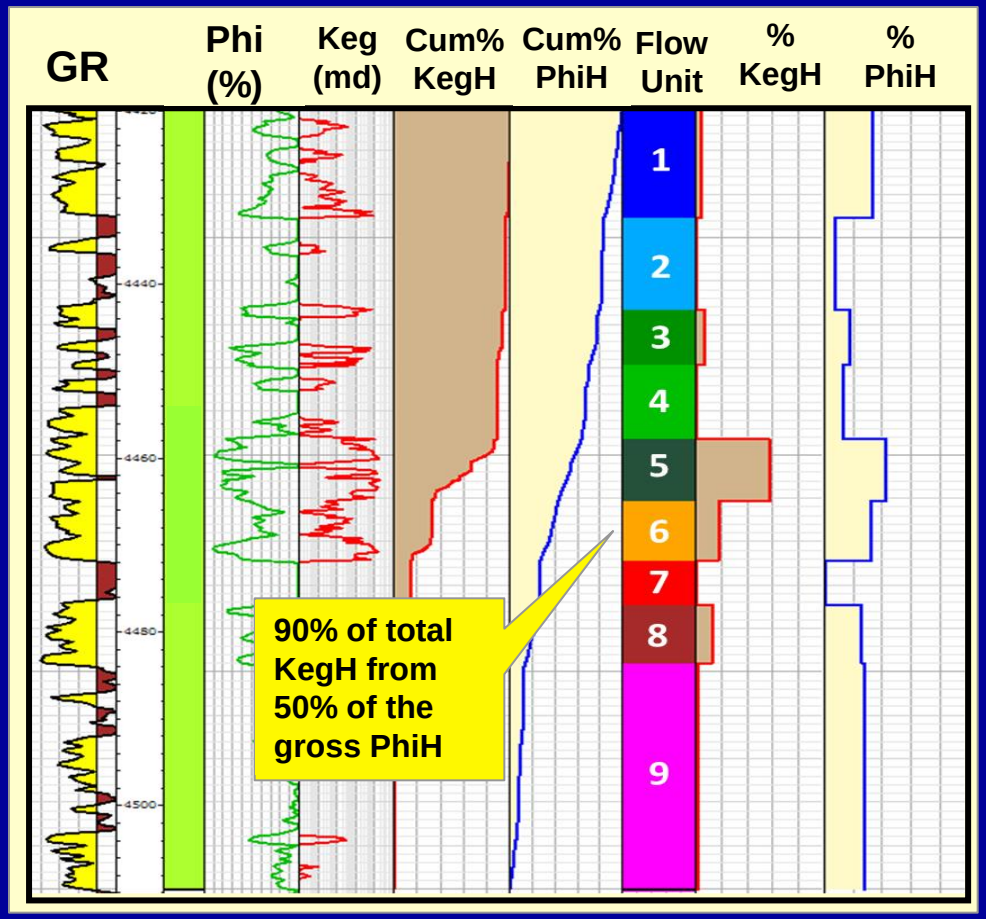
- Fundamentals matter – QA/QC!
- Develop saturation models
- Use with rock types to derive gas effective permeability (Keg)
- Summarize volumetrics, fractional flow, and deliverability profiles



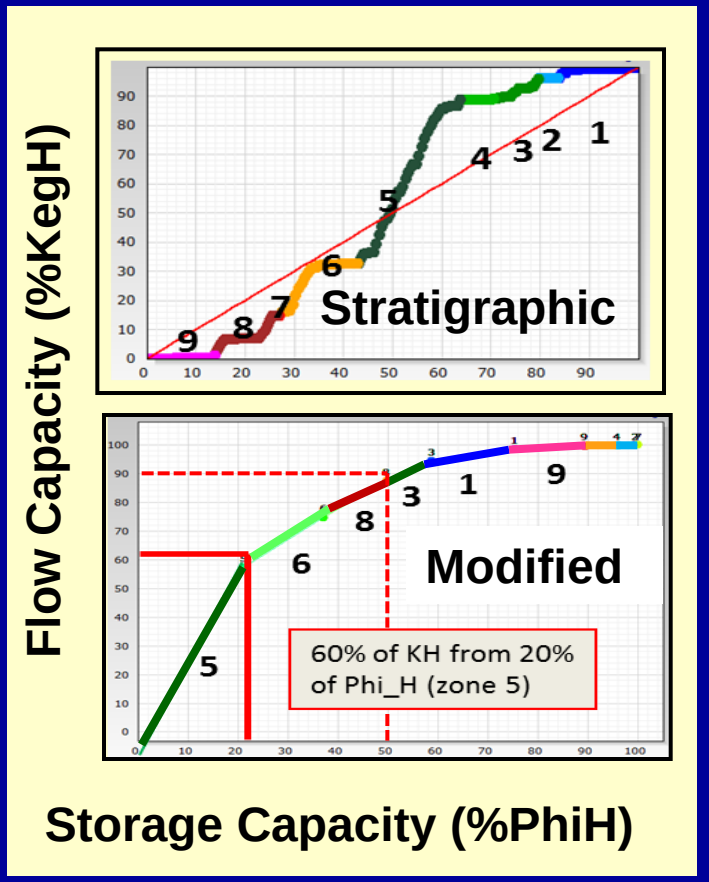
Flow Units

- The division of the reservoir into “flow units” provides a better input into numerical flow simulation

Stratigraphic Flow Profile

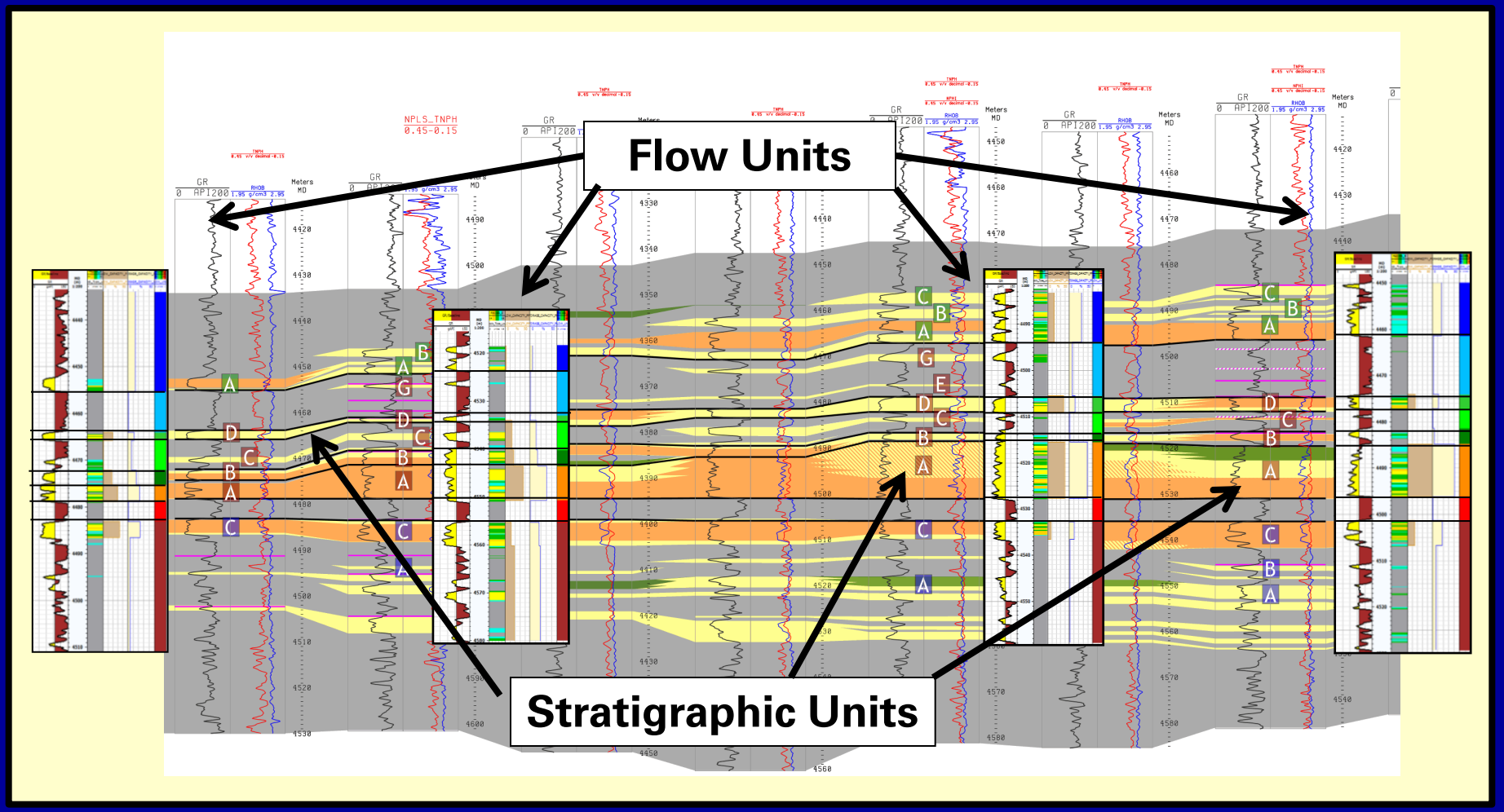


Lorenz Plots

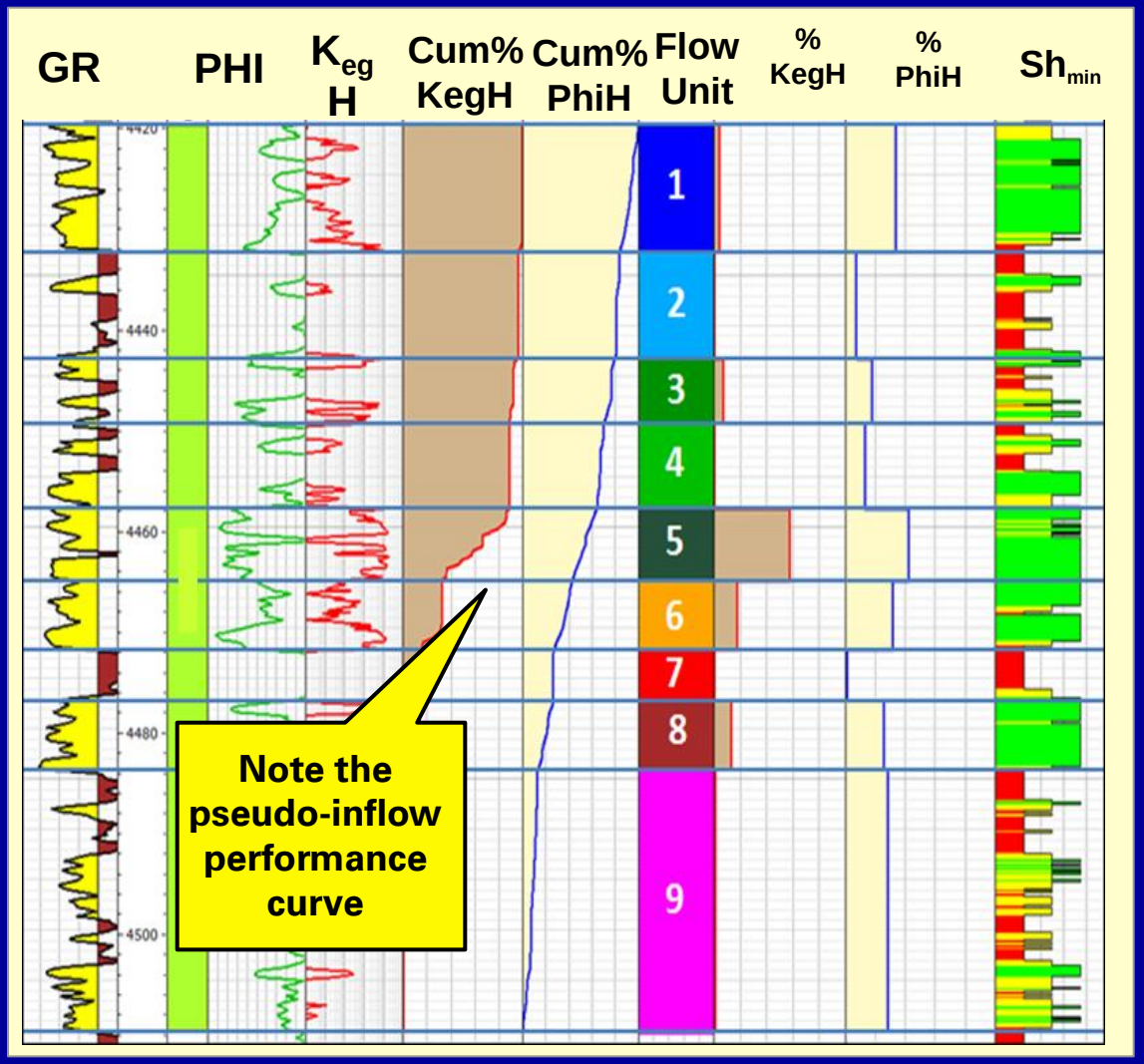


Are the Flow Units Correlative?

- Make sure the flow units make geologic sense!

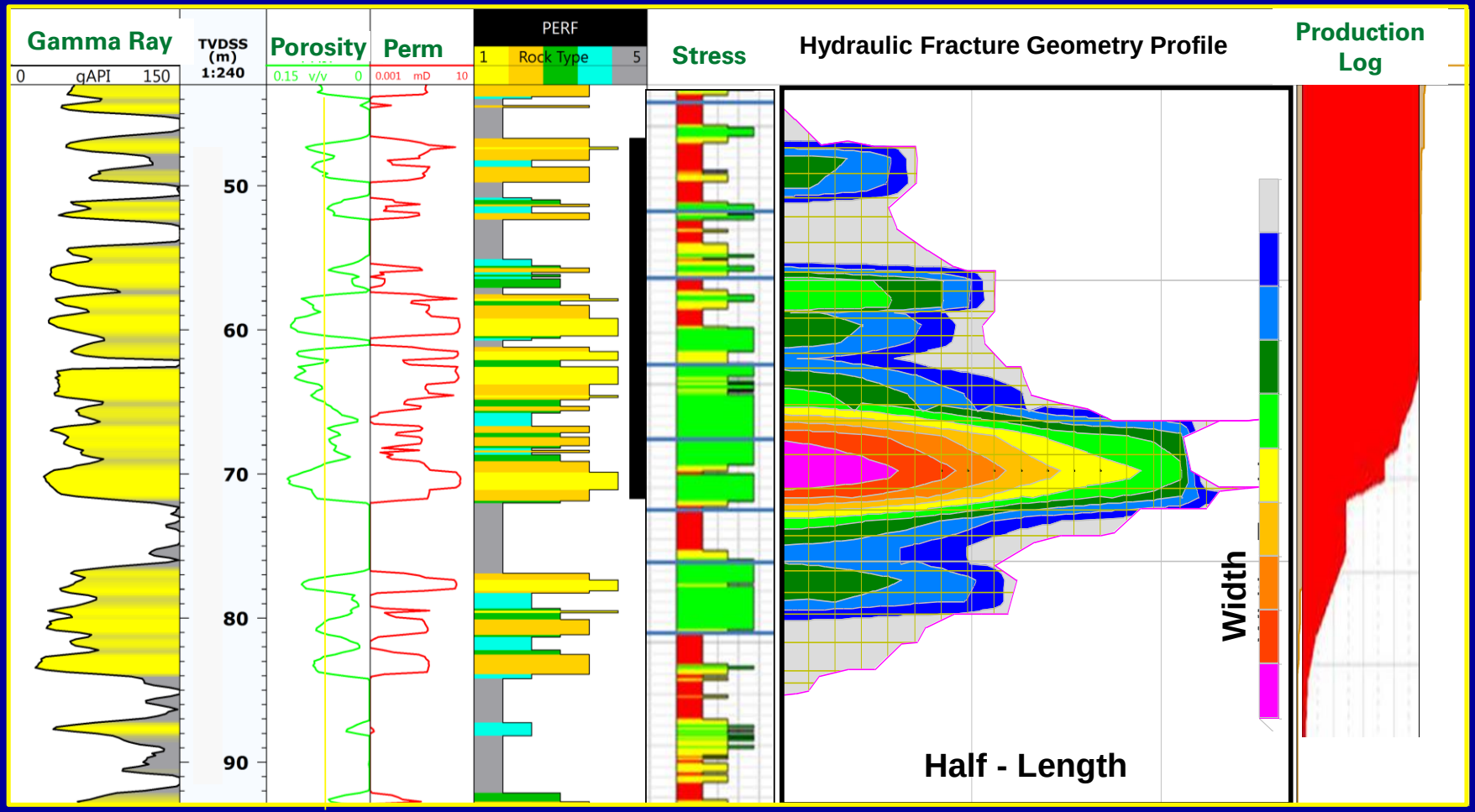


Putting it all together



- Flow unit 1: low stress significant storage capacity, but low flow capacity
- Flow unit 3: moderately to highly stressed shales and silty sands
- Flow units 5, 6, and 8 are ideal targets – low stress with high flow capacity

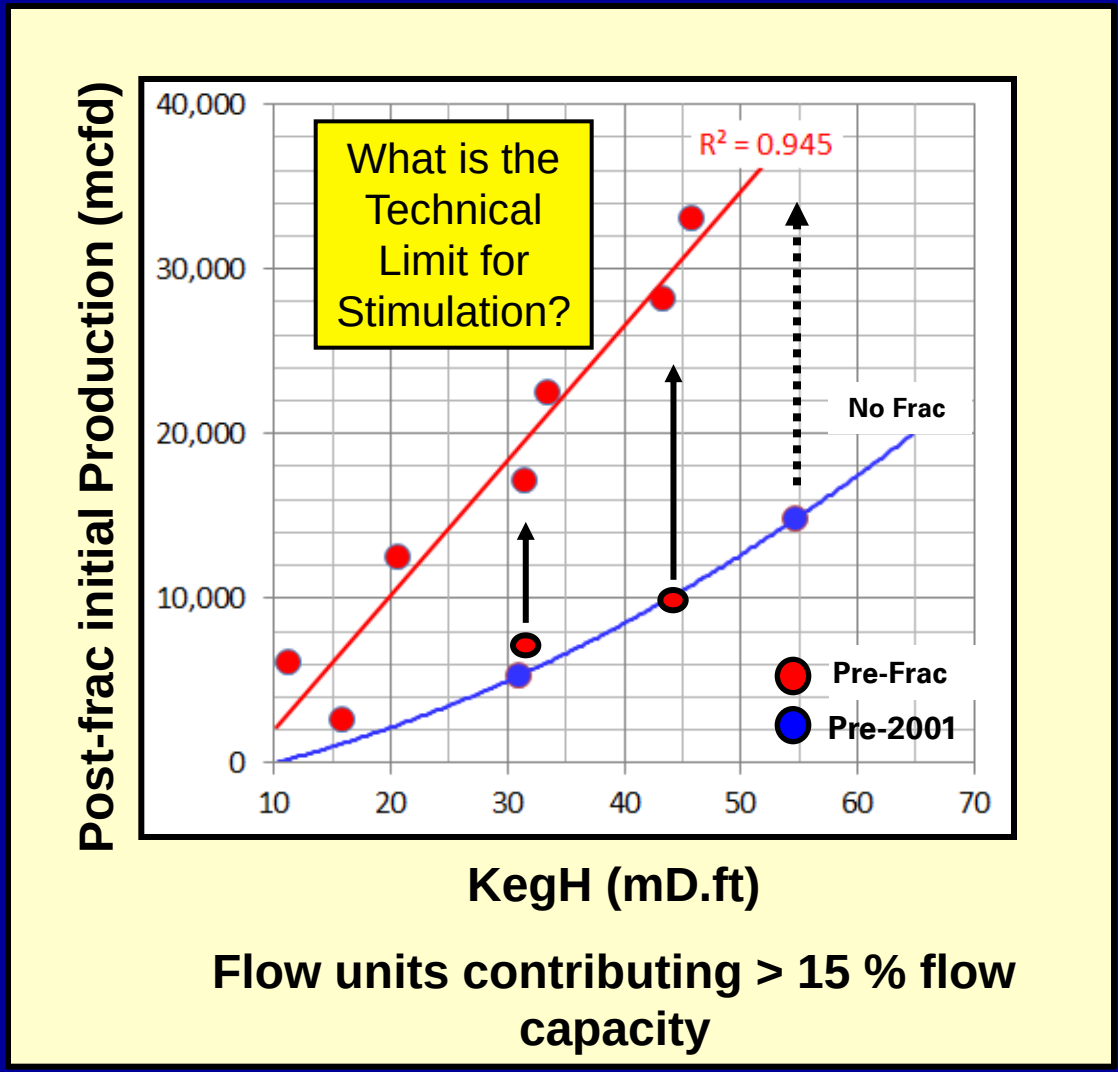
Flow Units to Frac Models



Optimized frac design delivers the best production !

Benchmarking for Completion Optimization

- Ongoing calibration of KegH with well tests
- Performance Prediction
- Conversation on completion efficiency



Uncertainties

- Coring and logging artifacts
- Saturation models and assumptions
- Statistical predictions from logs
- Static-dynamic tests vs volumes
- Tectonic corrections are both non-linear and non-isotropic
- Surveillance and learning are required!

Conclusions

- Efficient unconventional resource appraisal should include stress profiling and flow unit mapping.
- Prioritize those units with highest potential for deliverability – they will dominate the well and field performance.
- Integrated subsurface and completion workflows lead to improved capital efficiency and well performance.
- Continuous learning and improvement is a must!

Unconventional reservoirs require a new petrophysical paradigm – Beyond Volumetrics!

Distinguished Lecturer Program

Your Feedback is Important

Enter your section in the DL Evaluation Contest by completing the evaluation form for this presentation
Visit SPE.org/dl

Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl