



# Death by Bubble Point: Fact or Fantasy?

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# What's the Problem? This ...

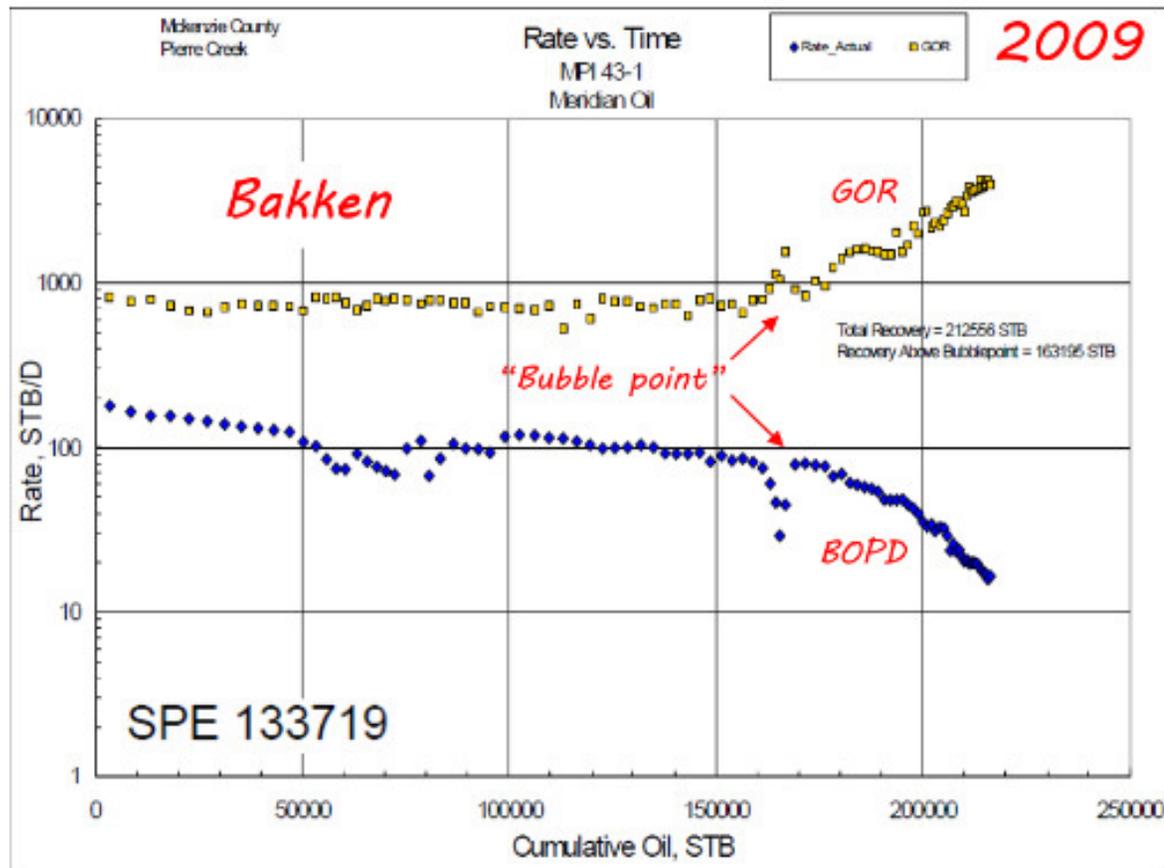
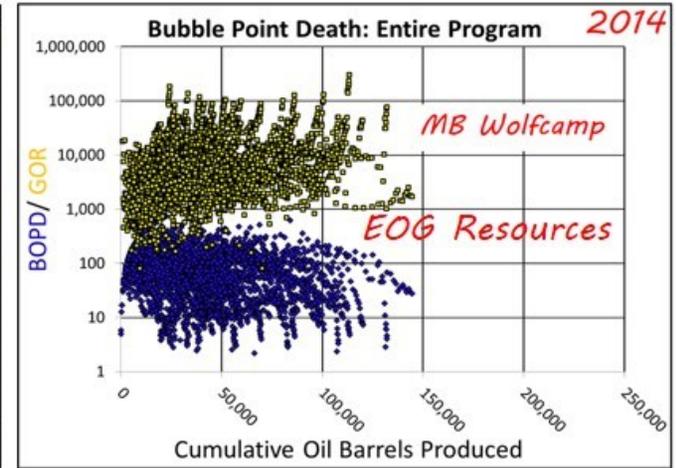
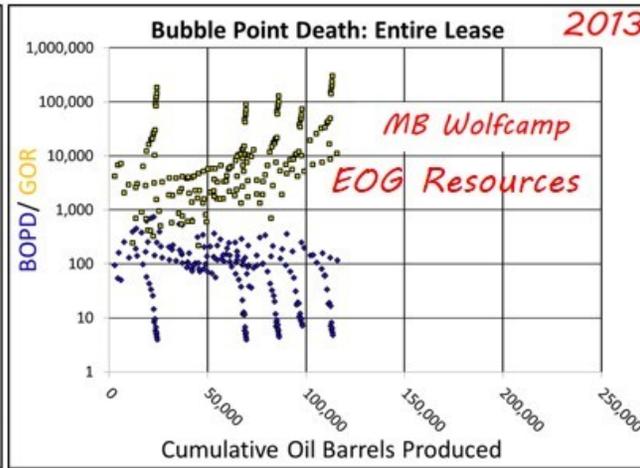
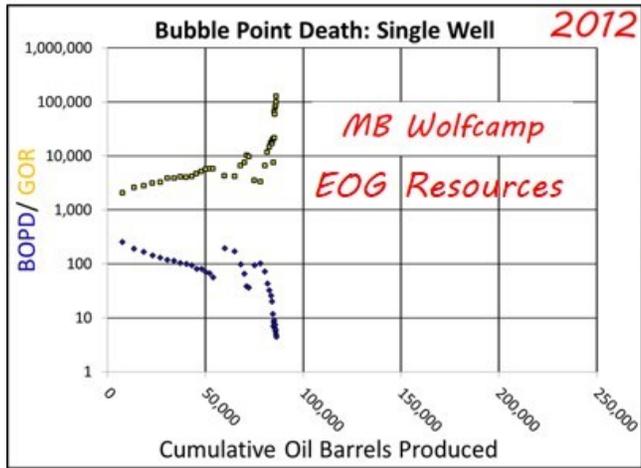


Fig. 5 – GOR vs. Cumulative production.

# And This ...



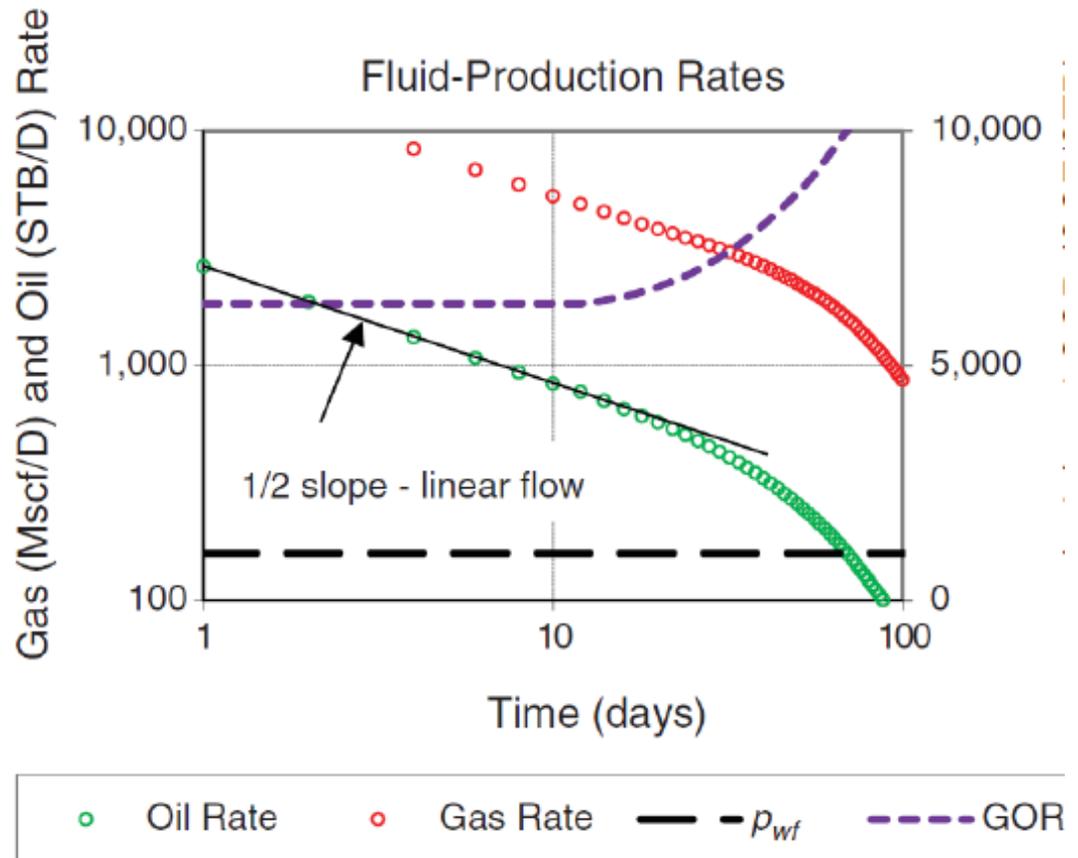
Source: Lapiere, 2017

# The Claim

- Tight, volatile oil wells in Permian Basin (and elsewhere) are declining more rapidly than operators have forecasted
- Oil production rate begins to decline rapidly just when GOR begins to increase
- The diagnosis: higher than expected GOR's, lower production rates develop as reservoir pressure drops below bubble-point pressure

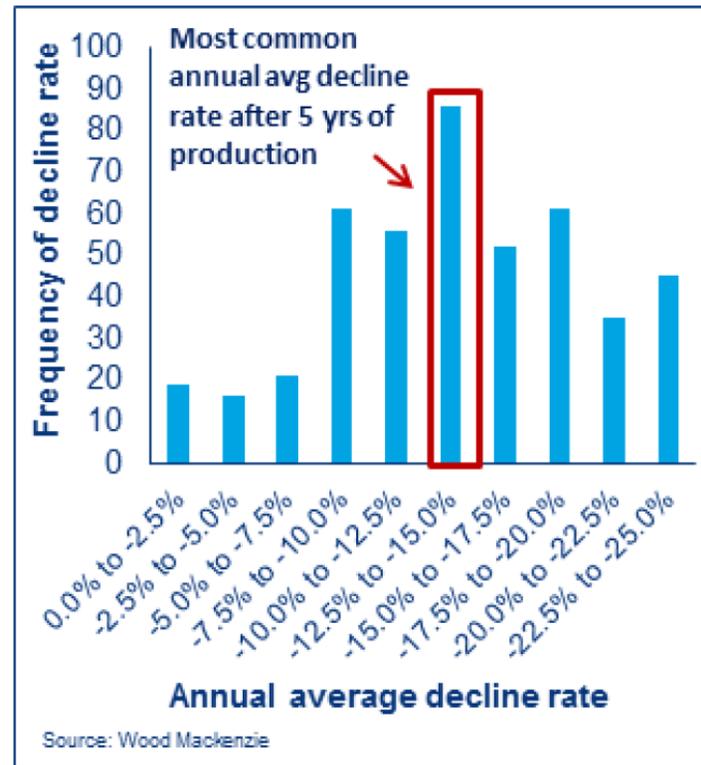
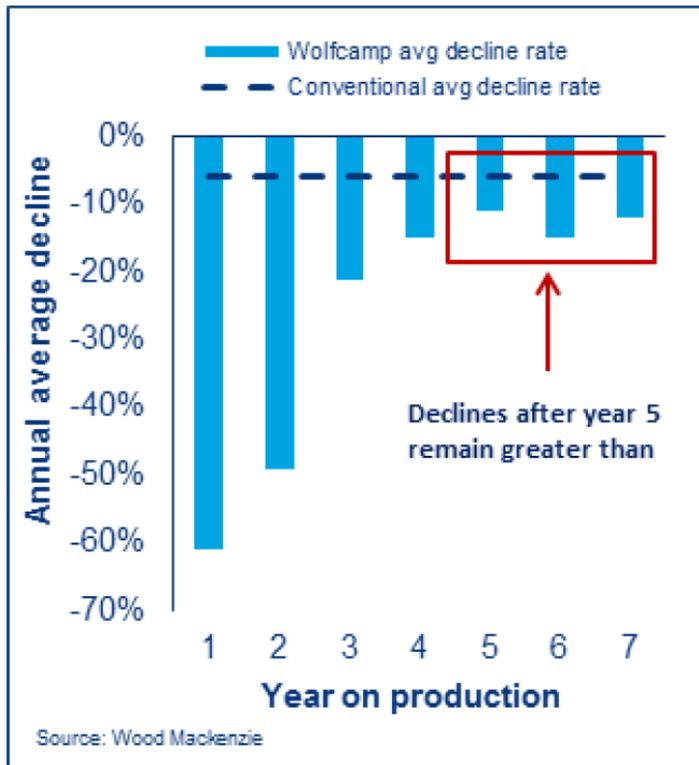
# Response to Claim (Fulford 2018)

Clarkson (SPE 178665) showed that GOR begins to increase when transient linear flow ends, and rate decreases whenever linear flow ends – the real cause of accelerated decline

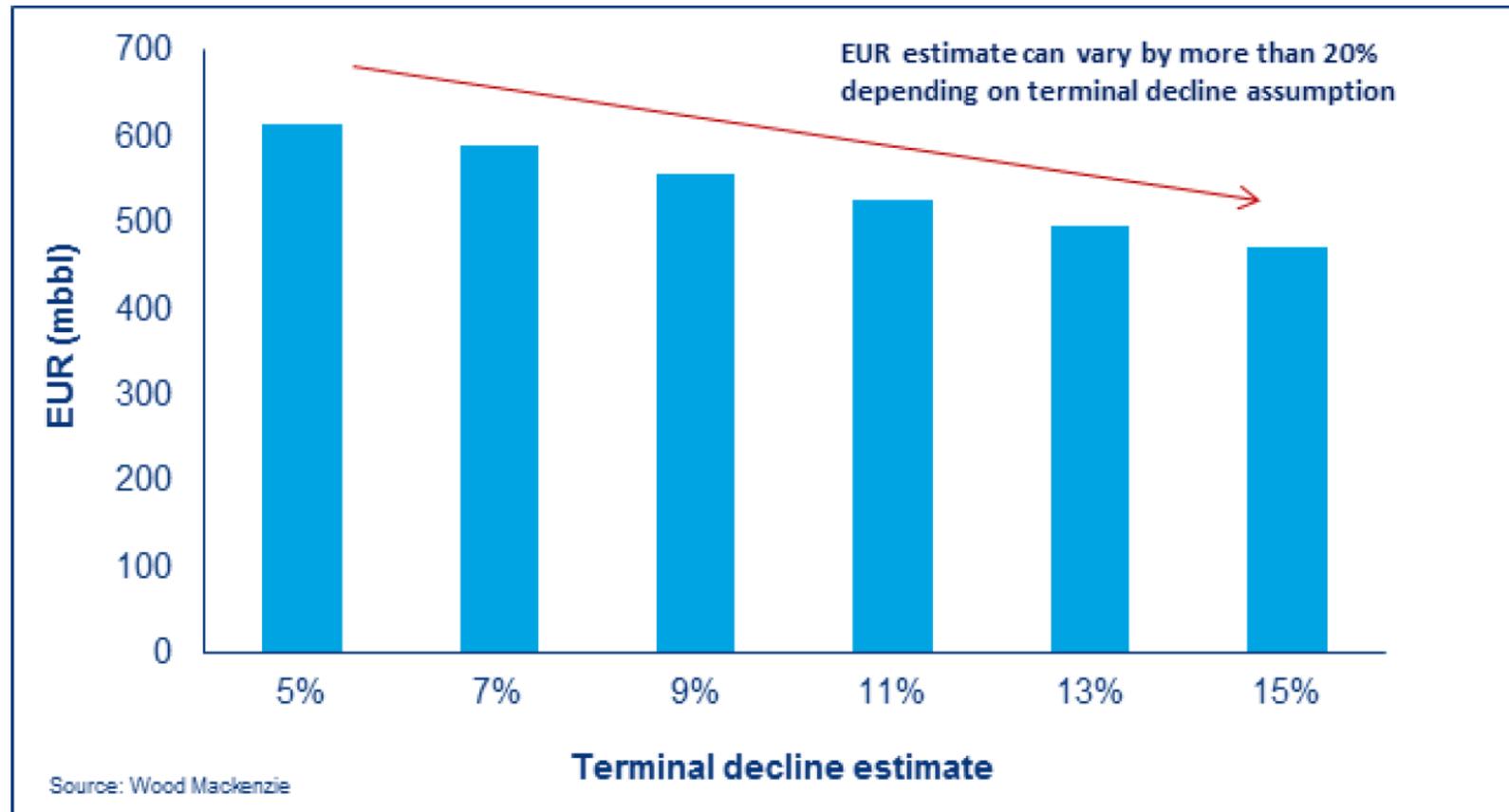


# But a New Claim Arises ...

Distribution of Midland WC Deep Basin declines after 5 years



# Implications of Higher $D_{min}$

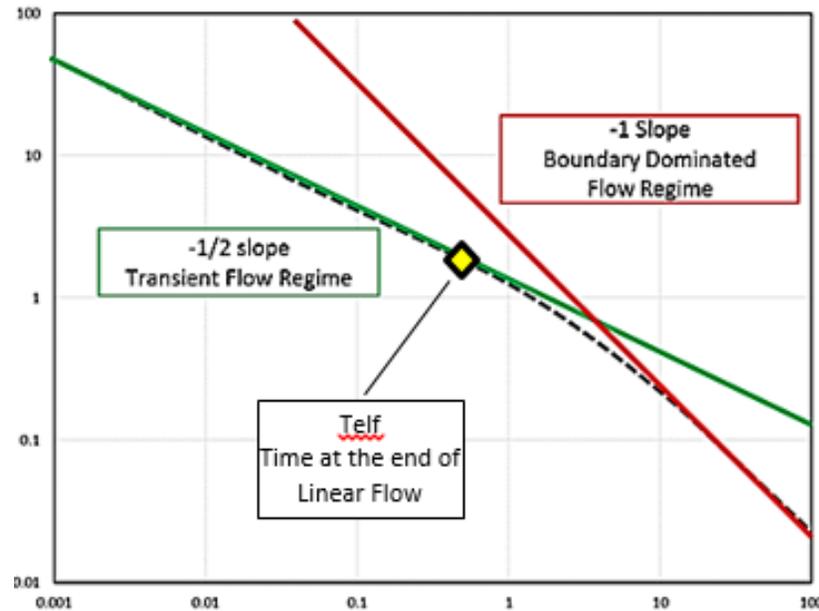


# Wood Mackenzie Interpretation

- Many forecasts for volatile oil wells in Permian Basin use  $D_{min}$  of 5-10% based on older vertical wells
- W-M concludes that *12-14% terminal decline* more likely
- *Higher terminal decline rates not attributed to increasing GOR's* – but could be by others
- Higher terminal decline rates impact EUR's, but 5-year NPV affected less

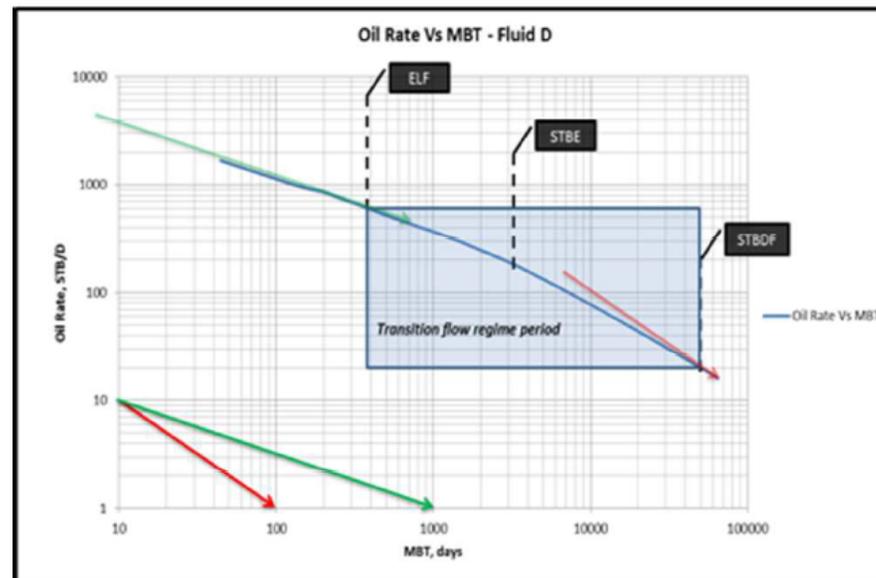
# What Can We Learn from Theory?

- Wattenbarger type curve: transient linear flow followed by boundary-dominated flow
- Assumes *single-phase flow*, predicts relatively short transition period



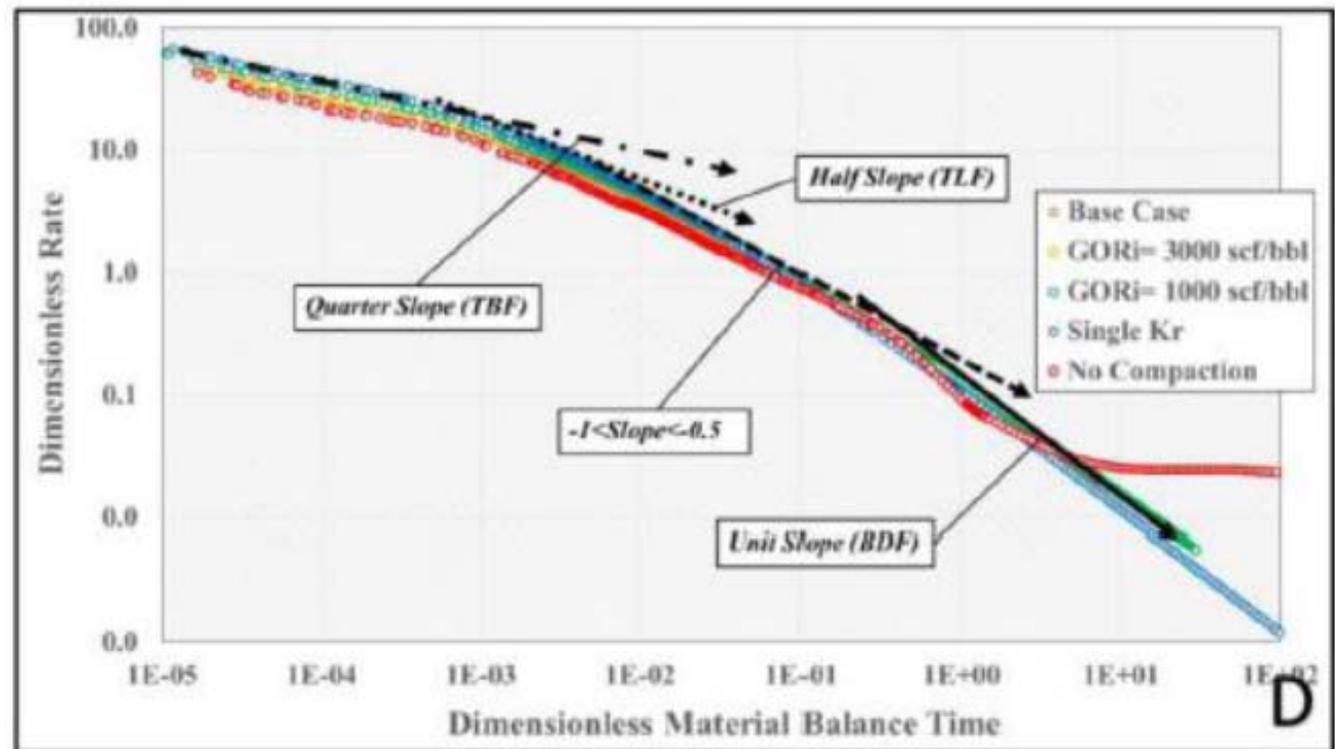
# What Difference Does Multi-Phase Flow Make?

- From composition simulation, URTeC 2429922
  - Much longer transition period
  - Data in transition region easily misinterpreted as “terminal decline”; decline rate at 5 years can be steep



# Attempt to Take Fluid Behavior in Nano-Pores into Account in Compositional Simulation

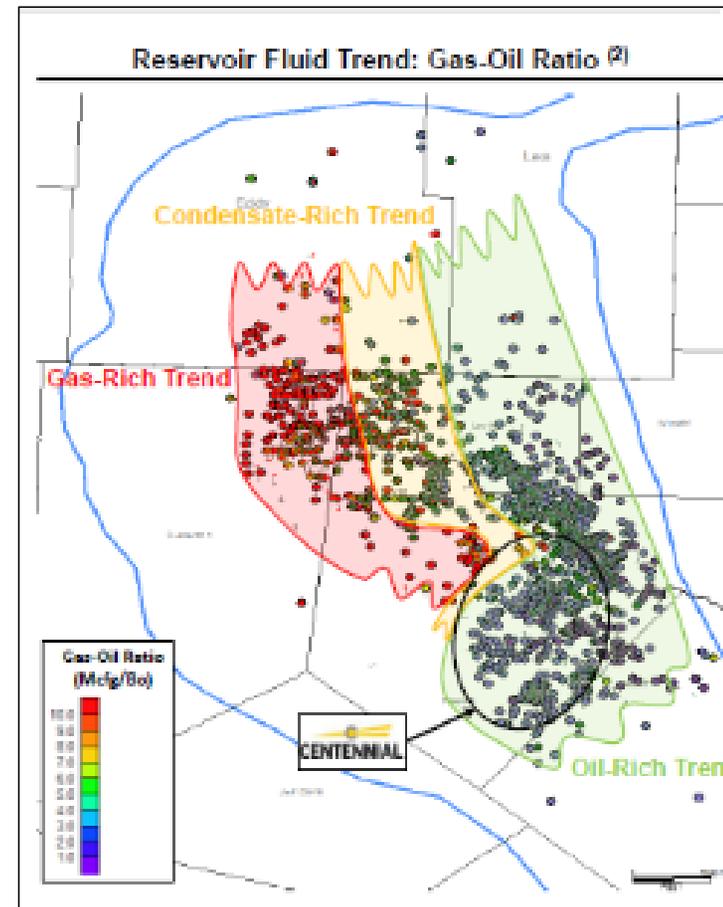
SPE 175137 –  
Note long duration of transition region between transient linear flow and BDF



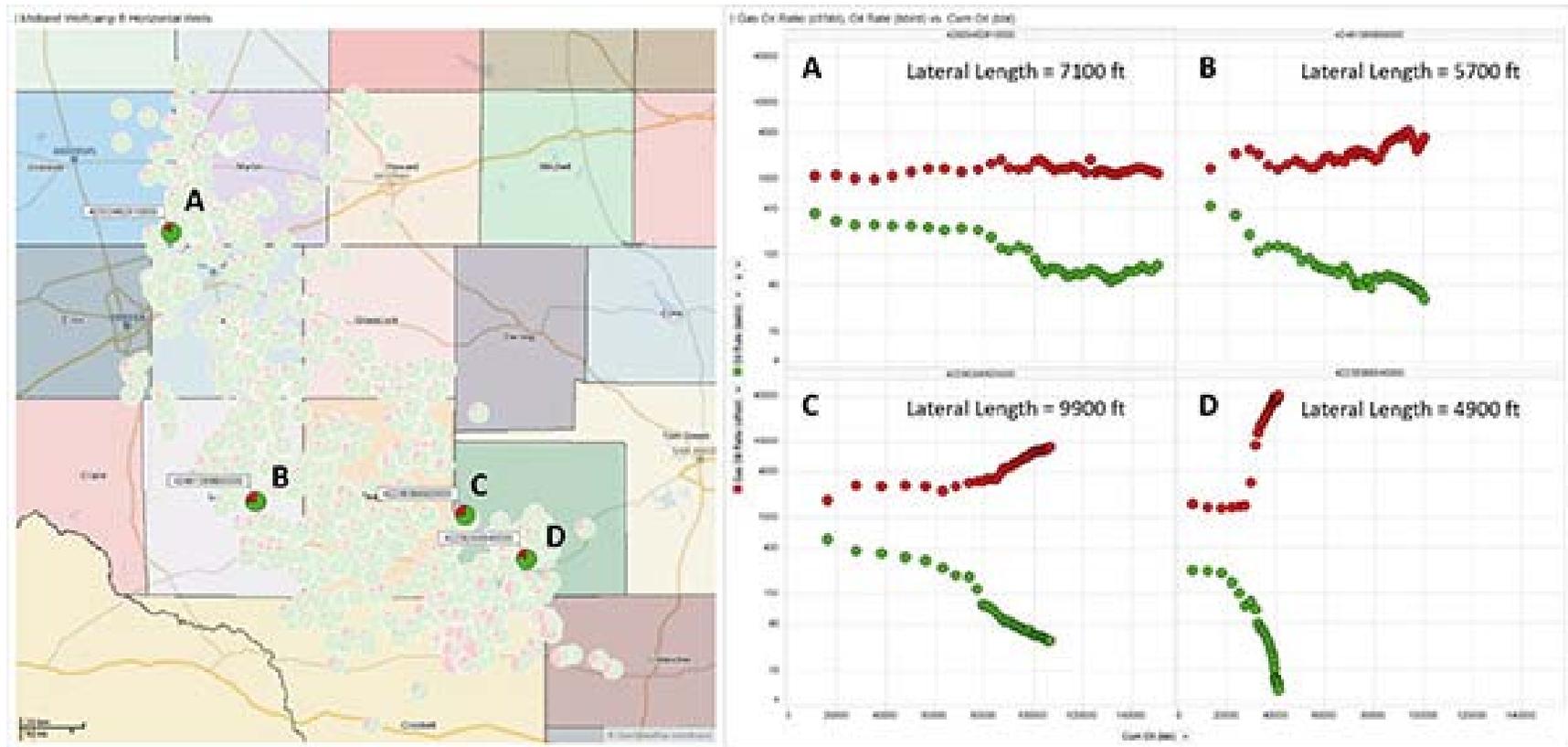
# What Have We Overlooked?

Fluid composition varies with location

- Bubble-point pressure thus varies, and GOR history will vary – one size doesn't fit all

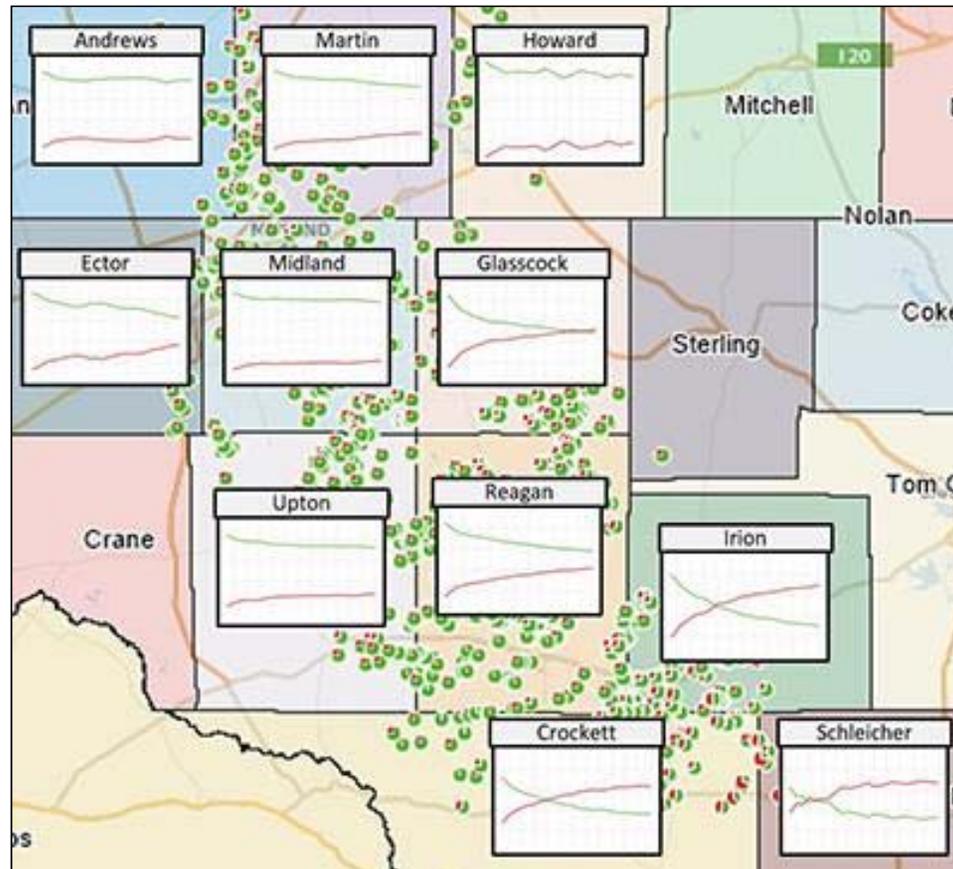


# Oil Rate and GOR Vary in Midland Basin



Source: Ground Truth, 2017

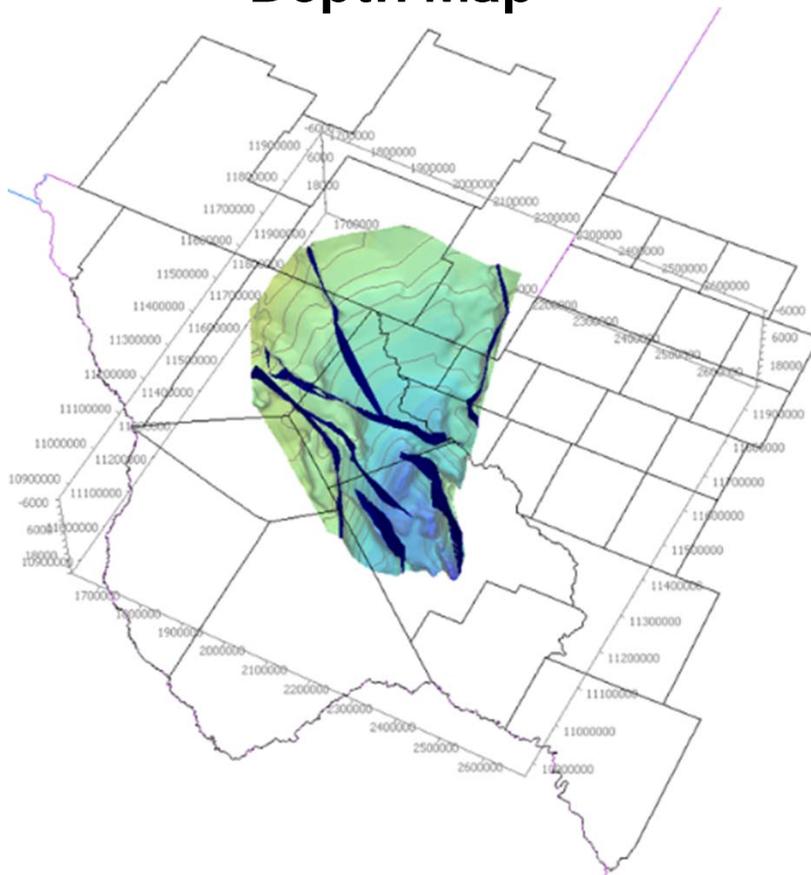
# More Evidence of Variation



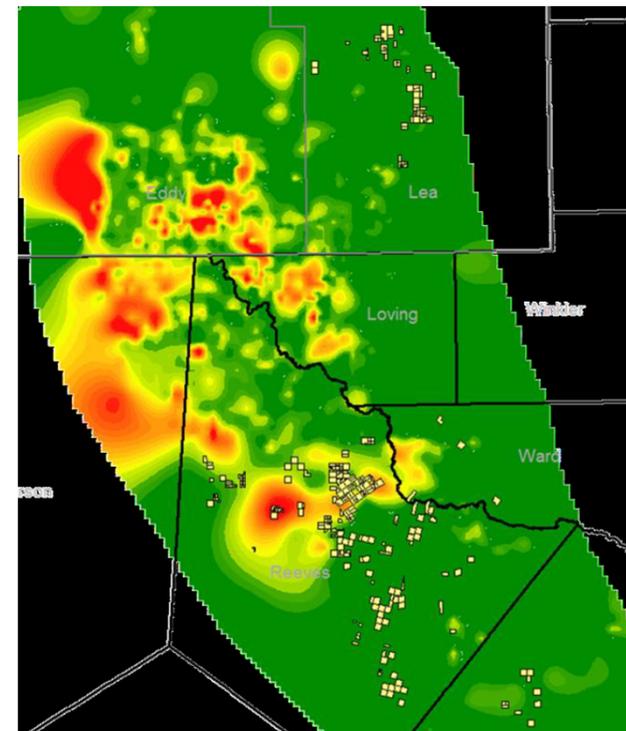
Source: Ground Truth, 2017

# Variability in GOR in Delaware Basin

Depth Map



GOR map



# Lots of Uncertainty, Lots of Unknowns

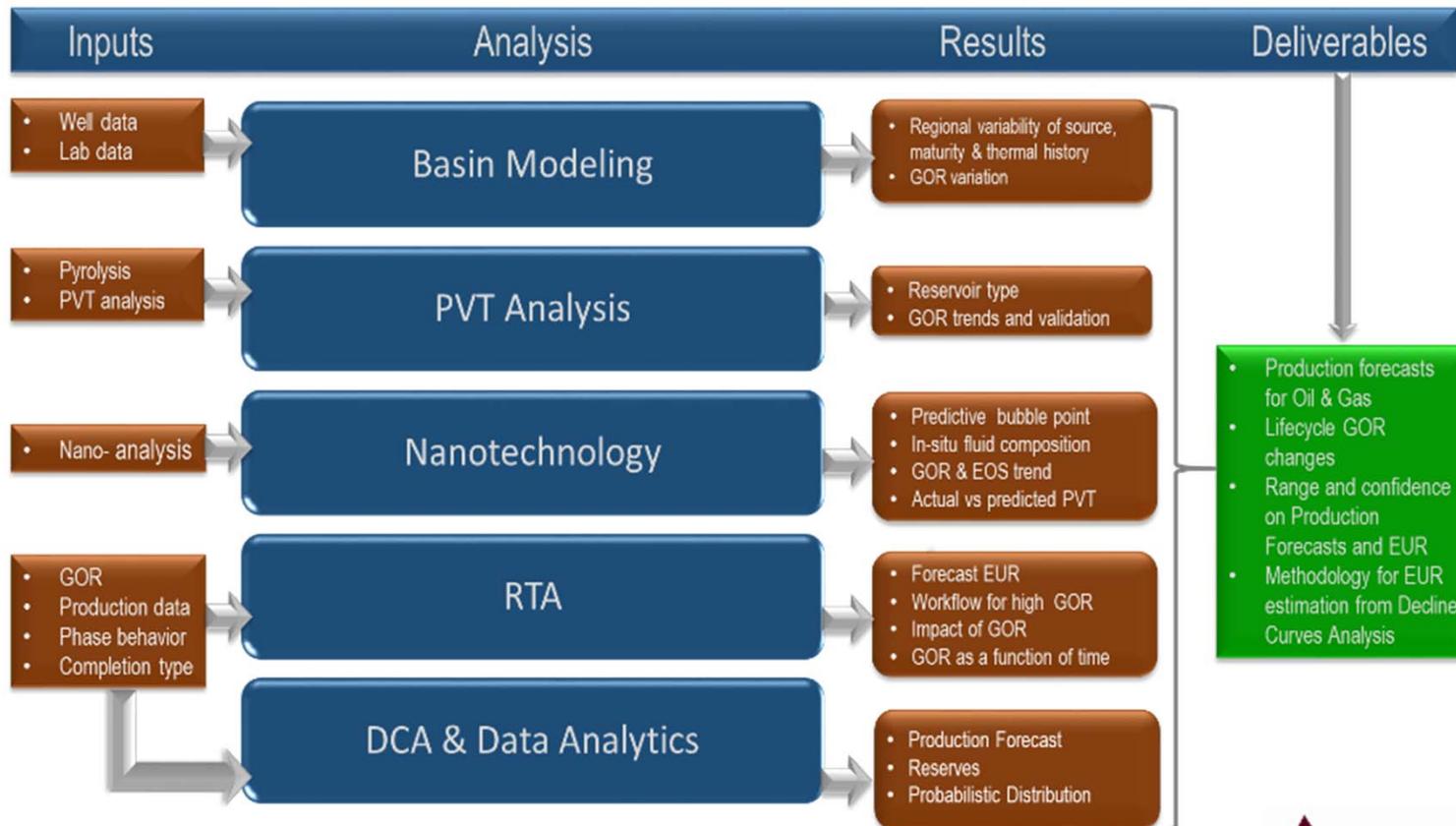
- Perhaps we should minimize intuitive interpretations and proceed with systematic, principles-based analyses
- *Berg-Hughes Center for Petroleum and Sedimentary Systems* at Texas A&M and Core Labs to undertake Delaware Basin study
- Project Title: “Delaware Basin GOR and Production Forecasting”

# Objectives of Study

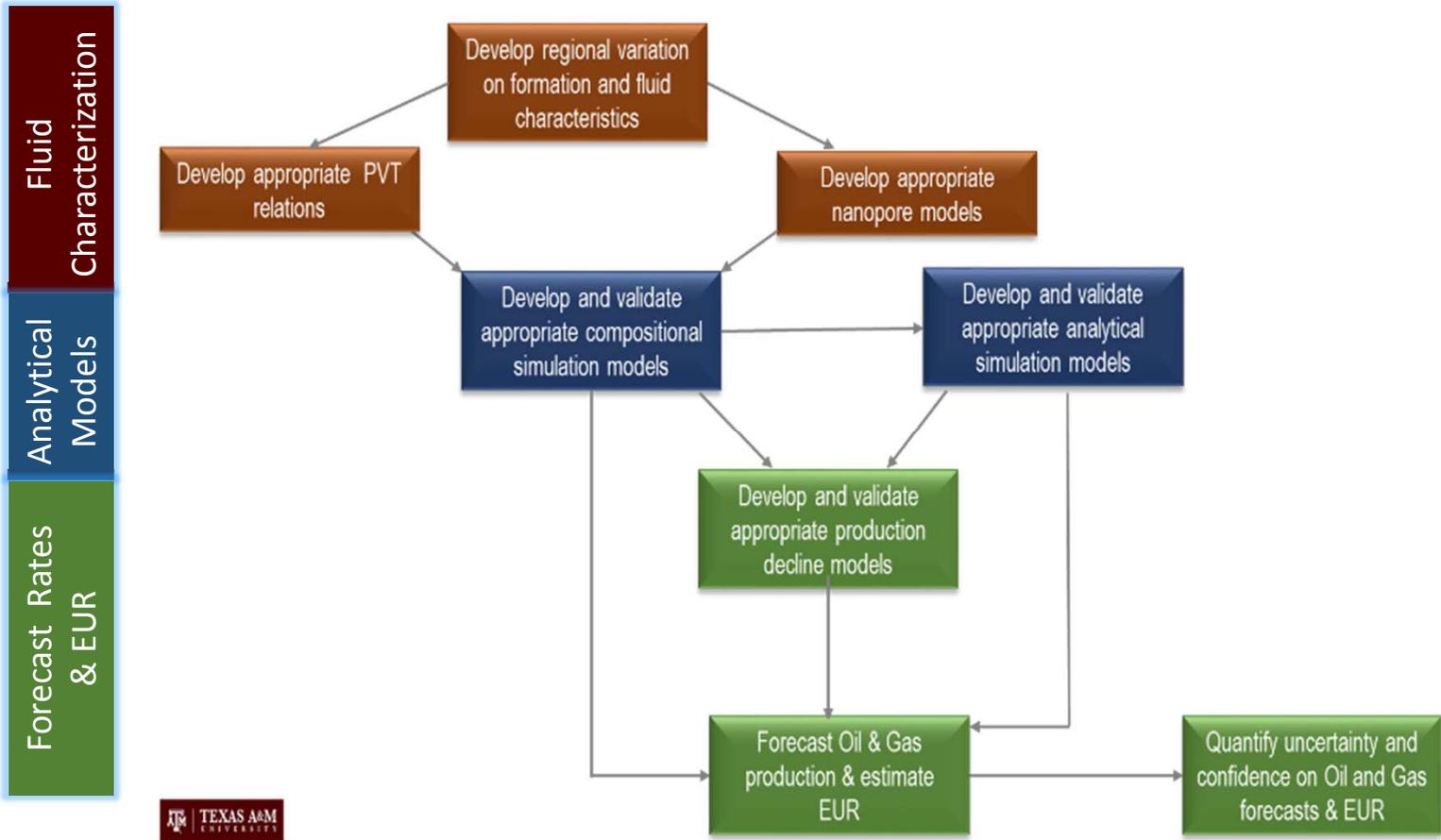
- Develop physics-based models to predict rate and GOR and provide basis for Decline Curve and Rate Transient Analysis
- Develop models to forecast rate and GOR as functions of time, cumulative production and other geoscience and engineering parameters
- Determine geological controls (source, thermal history, maturity and pore size/type) on GOR and fluid composition of the reservoir using experimental and basin modeling tools
- Infer controls and uncertainty in forecasted rates, GOR and fluid composition using data analytics
- Predict recovery factors and how they vary regionally

# Project Deliverables

## Delaware Basin GOR & Production Forecast Project-2018



# Project Workflow



# Project Deliverables

- Regional variation in formations and fluid characteristics in the Delaware Basin
- Impact of nanopores on phase behavior and transport of reservoir fluids in Delaware Basin
- New, quick-and-easy-to-apply method to interpret GOR-trend variations in Delaware Basin
- Projected lifecycle GOR changes
- Production forecasts for oil & gas for wells in Delaware Basin
- Range and confidence of production forecasts and EUR
- Methodology to estimate EUR to meet variety of needs including
  - nanopore storage and transport models
  - compositional simulators
  - analytical models (RTA)
  - empirical production decline models

# Quick Summary

- Several recent claims made that “the sky is falling” in Permian Basin tight oil reservoirs
- Logical rebuttal offered by some, but skepticism remains
- Some larger organizations have resources to study claims rigorously
- Other organizations may lack time and resources
- Berg-Hughes – Core Lab project may assist many to reach logical, defensible conclusions



Death by Bubble  
Point: Fact or  
Fantasy?

*Thanks!*