

Needs of Small Producers in Developing Unconventional Resources



Kashy Aminian, Ph.D.
Petroleum & Natural Gas Engineering
West Virginia University

RPSEA Workshop
February 2007



Appalachian Basin*

The Most Drilled and Least Explored Basin in The World

- The Remaining Hydrocarbon Resources in the Basin Exists in:
 - **Unconventional Settings**
 - Coal Seams
 - Devonian Shales
 - Low-permeability (Tight) Gas Sands
 - **Untapped Deeper Formations**

*IOGCC Publication



Small Producers

- **Limited Access to Capital**
 - Little room for trial & error

- **Limited Access to Expert Workforce**
 - To extend the life of the existing of wells
 - Economically find and produce resources in challenging settings



What is needed?

- **New Technologies for Maximizing ROI in Unconventional Resources.**
- **Make New Technologies Accessible and Usable**
 - Easy to Use Toolbox Development
 - Technology Transfer



What is needed?

- **Research to devise new techniques and algorithms is essential but not enough.**
- **Many good techniques have been developed that never made it in the hands of those who need them most.**



Technology Needs

- **MUST address the realities in the field:**
 - **Data Limitation**
 - **Expert Workforce Limitation**
- **Capable of providing reasonable results with limited data.**
- **Any new technology MUST be embedded into a user friendly software (Tool)**
- **Rigorous Technology Transfer MUST be associated with any new tool that is developed.**



Areas of Research & Development

Develop new techniques for:

- **Identifying Sweet spots in the reservoir**
- **Identifying underperformer wells**
- **Natural fracture detection**



Areas of Research & Development

Develop new techniques for:

- **Production data analysis**
- **Identification of infill locations**
- **Production enhancements through re-stimulation.**



Areas of Research & Development

Develop new techniques for:

- Increase efficiency of horizontal drilling in unconventional resources
- Reconciliation of 4D seismic interpretations with full field flow models
- revitalization of mature fields.



An Example Application

- Similar application can and should be developed for:
 - Tight Gas Reservoirs
 - *Under development – Used here as example*
 - Coalbed Methane
 - Challenges with Desorption Issues
 - Gas Shales
 - Challenges with Random Fracture Networks



Introduction

- Most mature fields were developed at a time when reservoir characterization was not a priority.
- The most common data that engineers can count on during analysis of mature fields is “Monthly Production Rate”.



Production Data Analysis

- Decline Curve Analysis (DCA)
- Type Curve Matching (TCM)



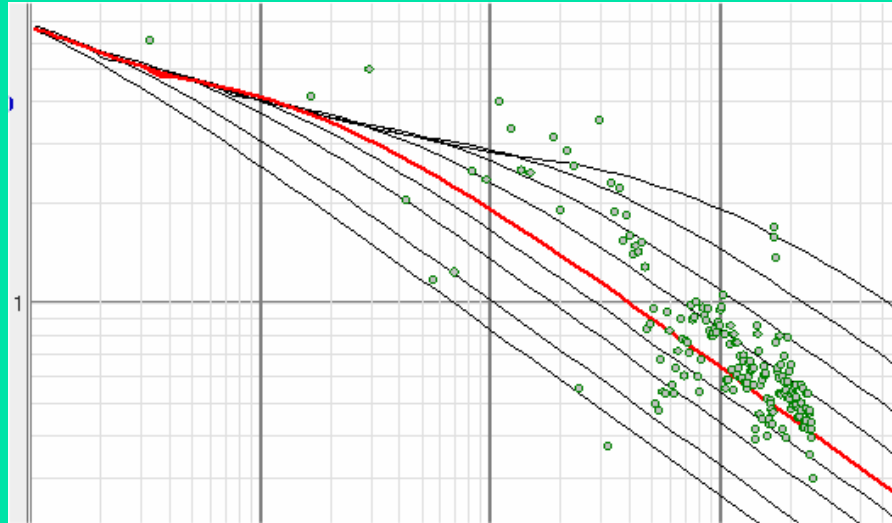
Shortcomings

- Almost all the techniques that provide some reservoir characterization as the result of production data analysis rely on bottom-hole or well-head pressure data.



Shortcomings

- Production data is noisy and many equally probable matches can be made for the same production data.
- This makes the process to be subjective and non-repeatable.





Shortcomings

- Addresses individual wells rather than the entire field.
 - Results of DCA and TCM procedures are based on single well (or lumped groups of wells)
 - Today's tools do not allow for integration of results from hundreds of wells into a cohesive field-wide or reservoir-wide analysis.



New Technique

- Unified & Comprehensive Production Data Analysis Technique:
 - No need for pressure data
 - Minimize subjectivity
 - Address the entire field (reservoir)
 - Reasonable repeatability
 - Identify Sweet spots
 - Optimum remedial operations



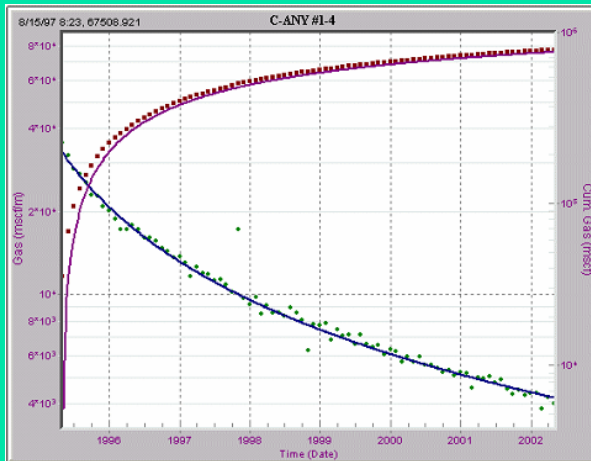
METHODOLOGY

- A Two Step Approach:
 - Step One:
 - Intelligent Iterative Integration, i^3
 - Step Two:
 - Fuzzy pattern recognition

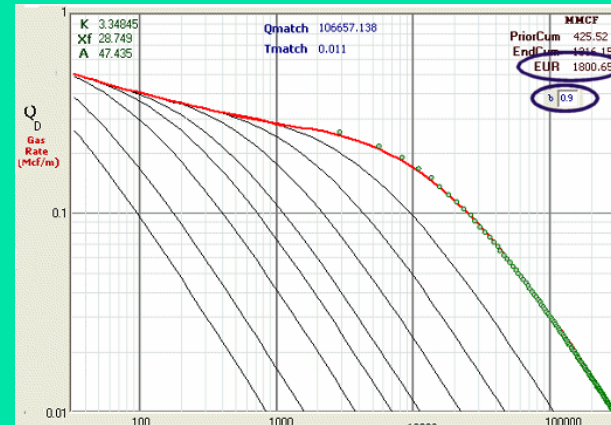


Intelligent Iterative Integration, *i*³

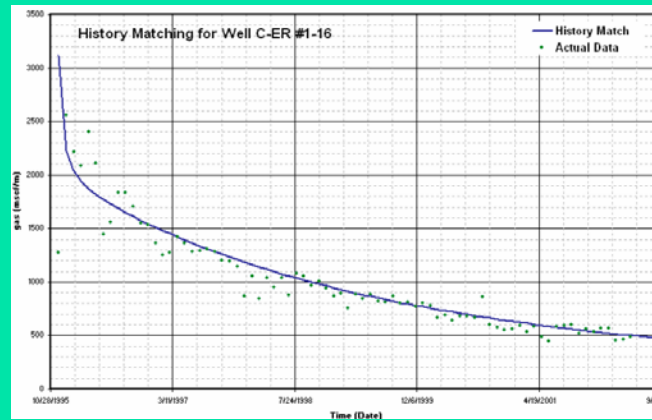
Decline Curve Analysis



Type Curve Matching



STEP ONE



Single-well numerical reservoir simulation



COMBINED DCA & TCM

Well Name	Decline Curve Analysis				Type Curve Matching			
	Qi (MSCF)	Di	b	EUR (MMSCF)	K (md)	Xf (ft)	A (ac)	EUR (MMSCF)
C-LL#1-28	40,500	0.051	0.51	1,449.3	3.45	35.8	73.4	1,455.5
C-WBY #1-1	28,130	0.057	1.15	1,709.6	2.09	28.3	48.1	1,671.6
C-AN #2-27	47,830	0.248	1.30	1,314.8	3.78	29.3	17.7	1,328.3
N-CERO 3-3	6,333	0.026	1.80	800.8	0.18	27.2	6.8	809.6
T-DLE A#1	10,894	0.268	1.42	318.9	0.75	8.6	4.2	318.5

“b” from DCA is used to identify the most likely type curve to use for matching and matching EUR from DCA & TCM is used to find the most likely set of reservoir characteristics.

To be used in History Matching along with the default parameters

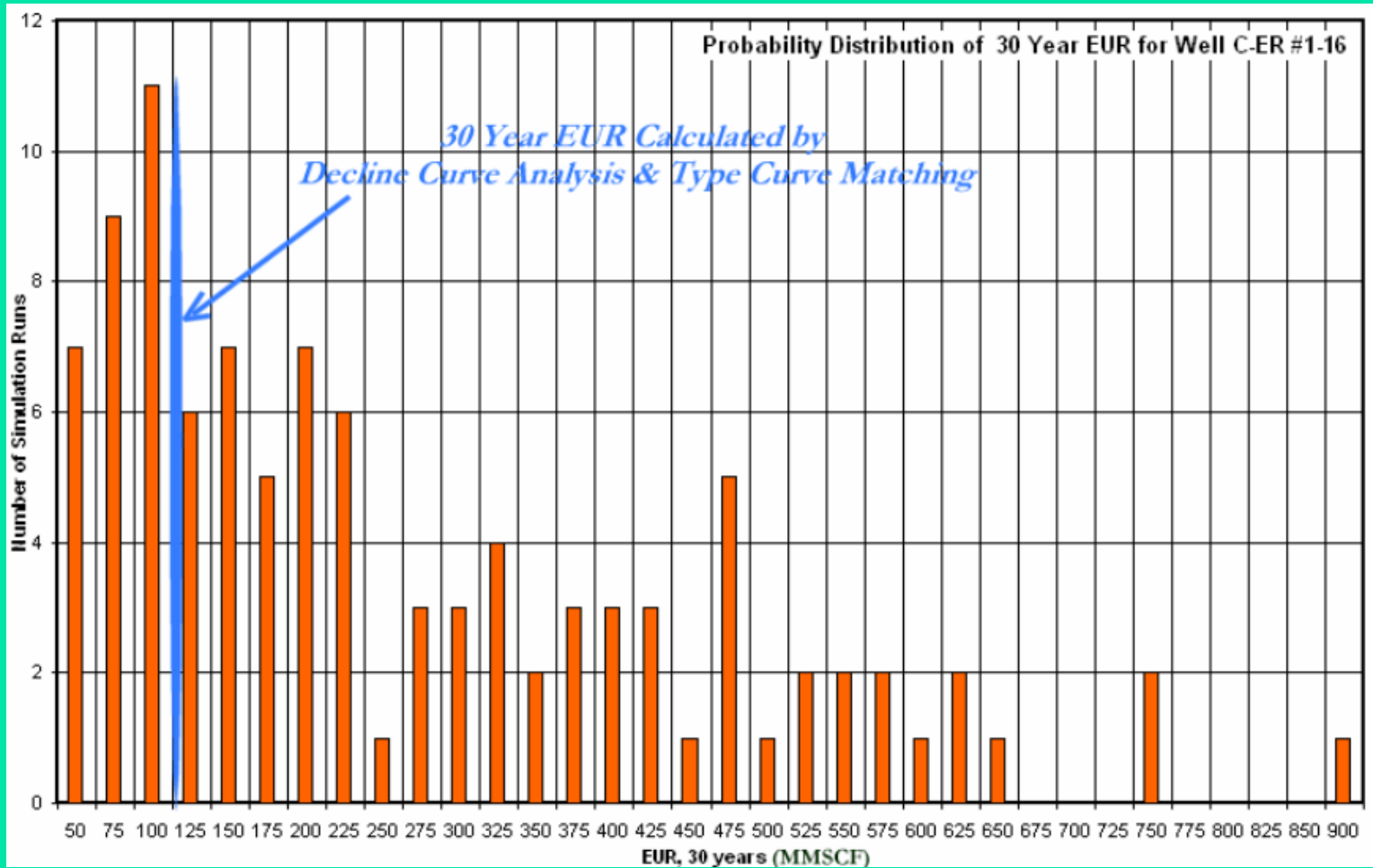


RESERVOIR SIMULATIONS

- Use the results of type curve matching procedure as a guideline to achieve reasonable history match.
- The reservoir characteristics from the history match may be somewhat different from those calculated during Type Curve Matching.
- Monte Carlo Simulation is used to resolve the differences.



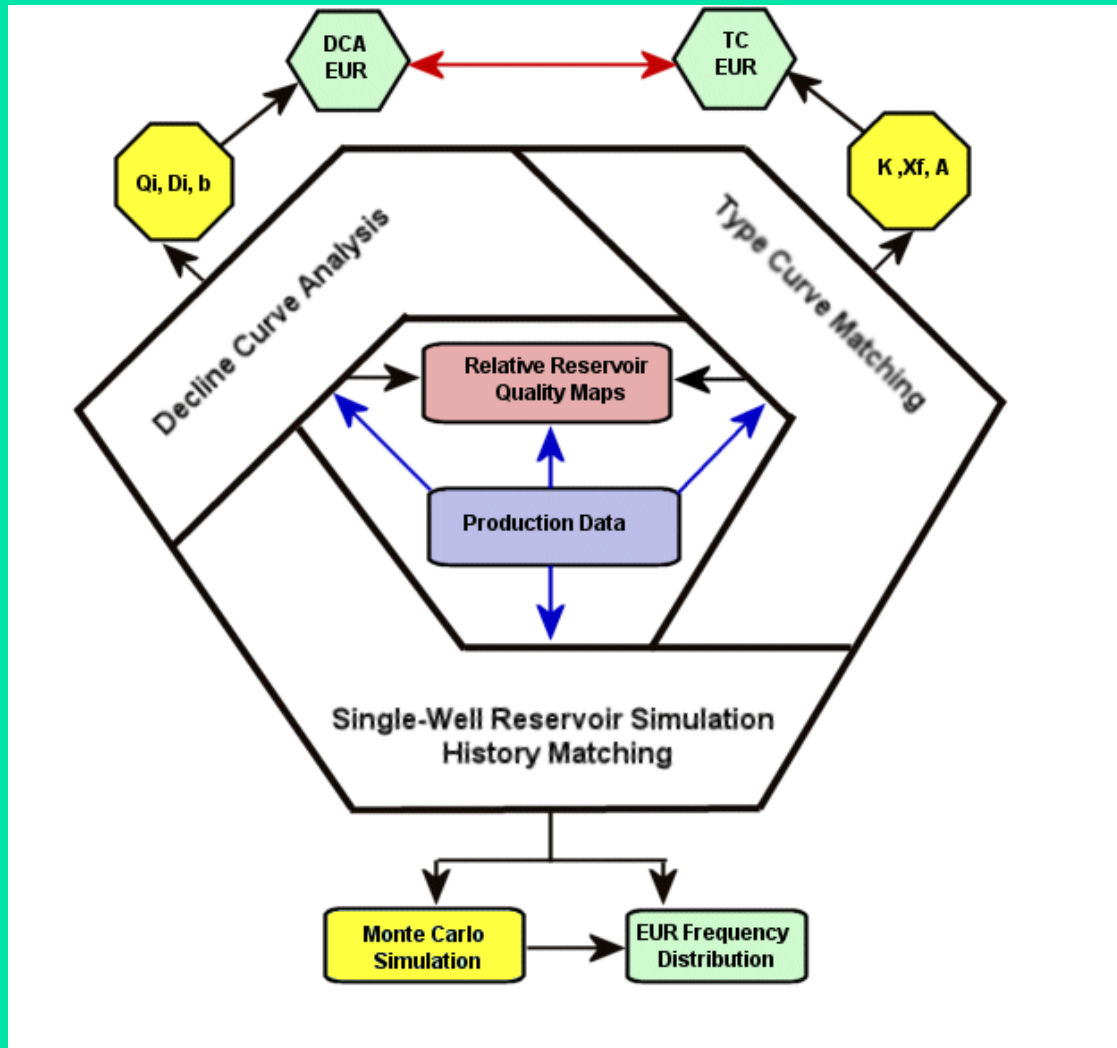
MONTE CARLO SIMULATION





THE WORK FLOW

STEP ONE





Fuzzy Pattern Recognition

- Super-impose reservoir characteristics from all wells in the field.
 - **Detect trends in the field.**
 - **Identify sweet spots.**
 - **Track fluid movement.**
 - **Identify remedial opportunities**

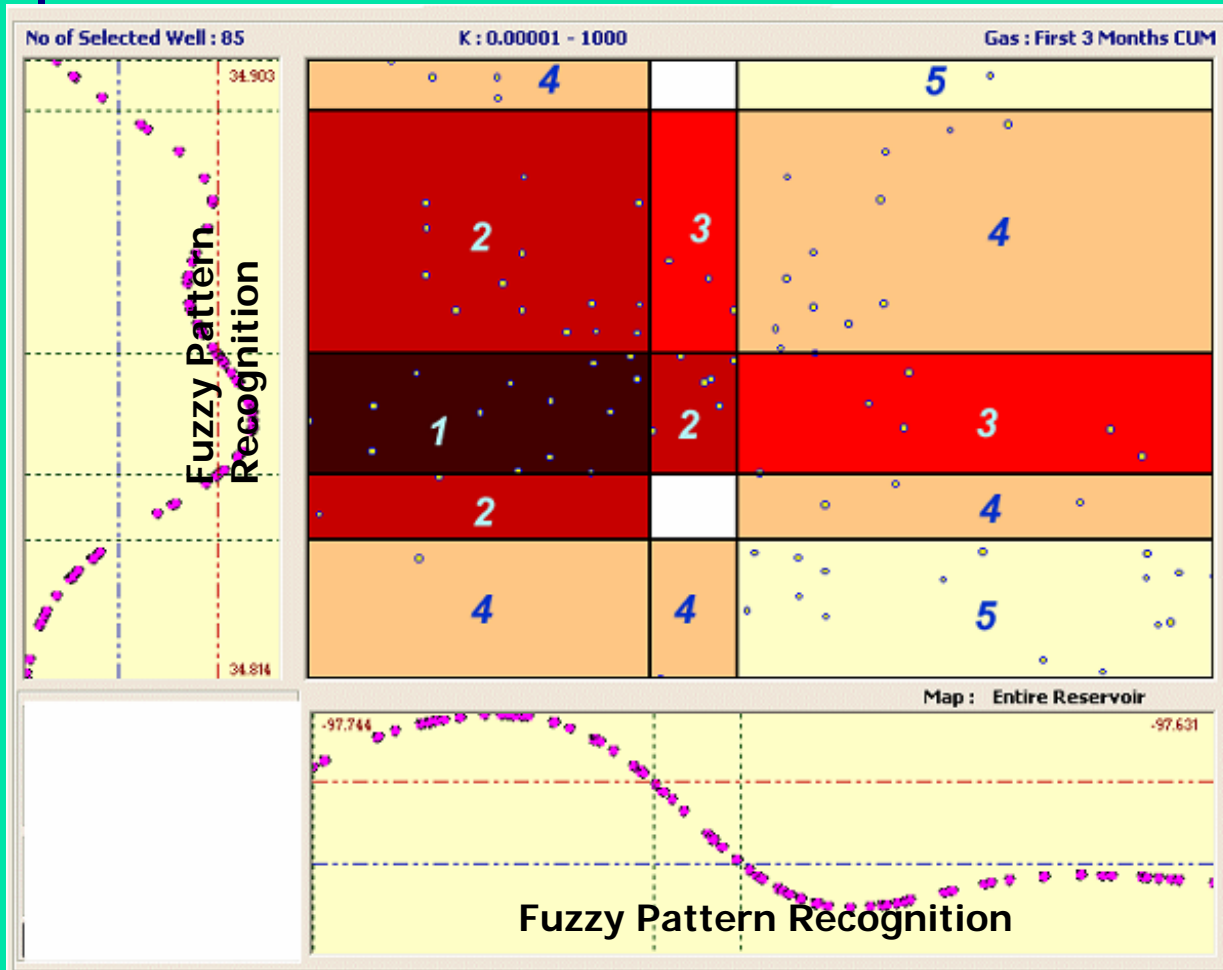


Reservoir Quality Index

- Two and three dimensional maps using production indicators such as:
 - First and Best 3 Months of Production
 - First and Best 6 Months of Production
 - First and Best 9 Months of Production
 - First Year of Cumulative Production
 - Three Year Cumulative Production
 - Five Year Cumulative Production
 - Ten Year Cumulative Production



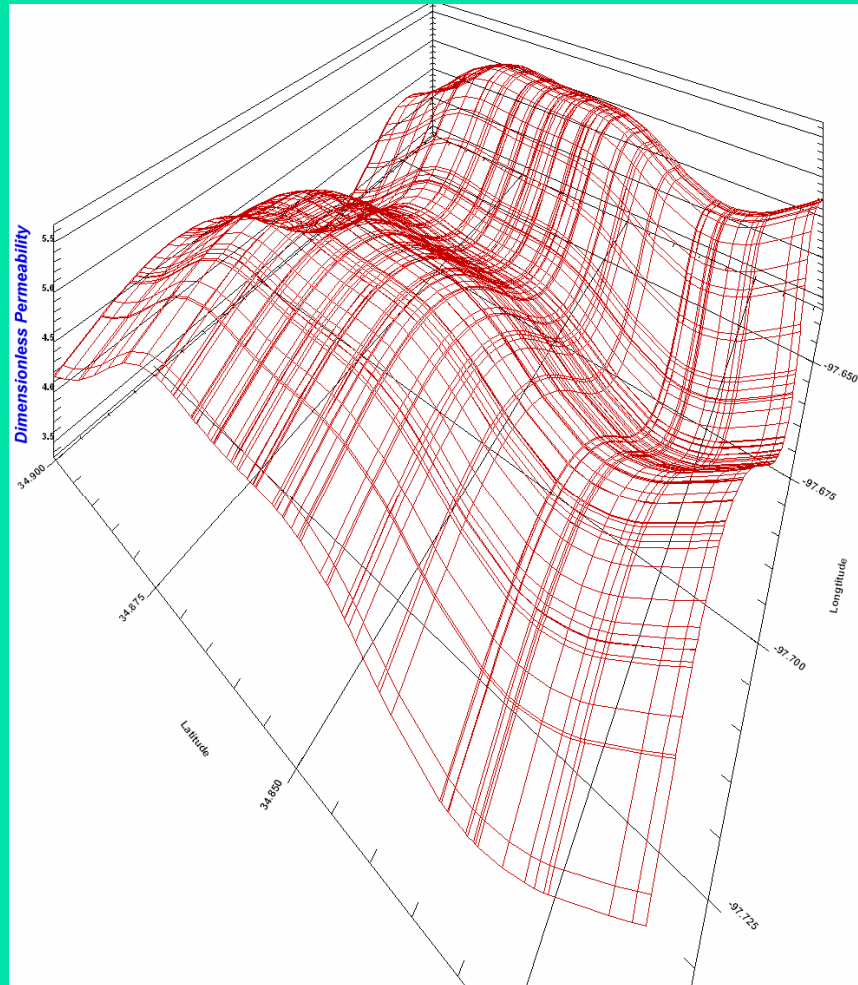
Reservoir Quality Index



Low Relative Reservoir Quality Index – RRQI represents higher quality reservoir characteristics.

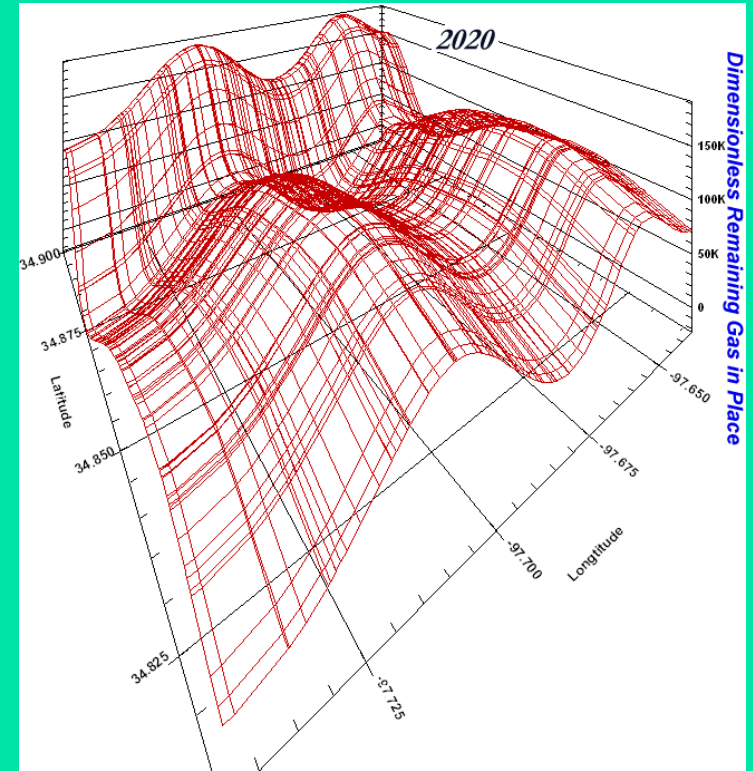
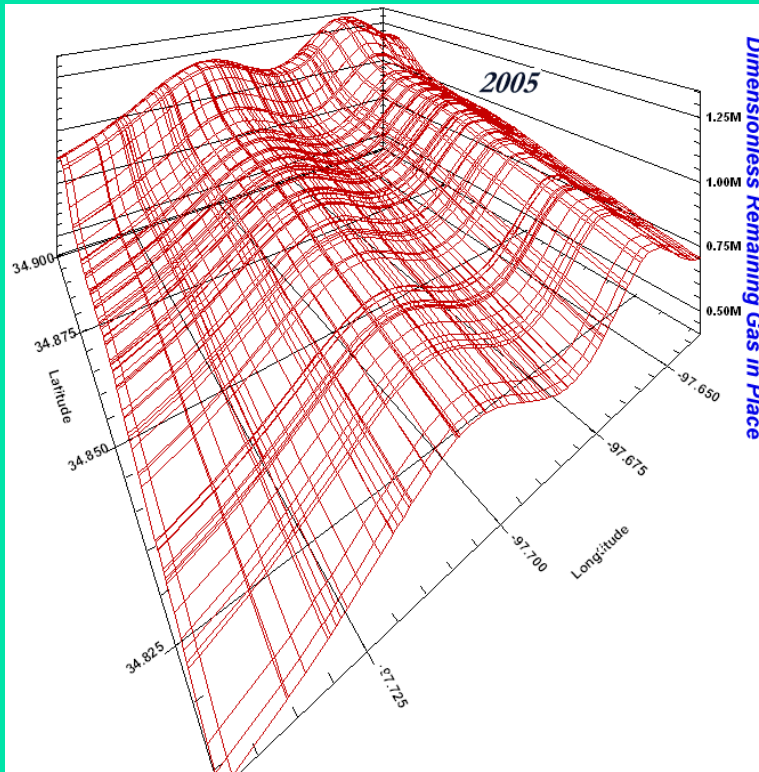


Reservoir Permeability



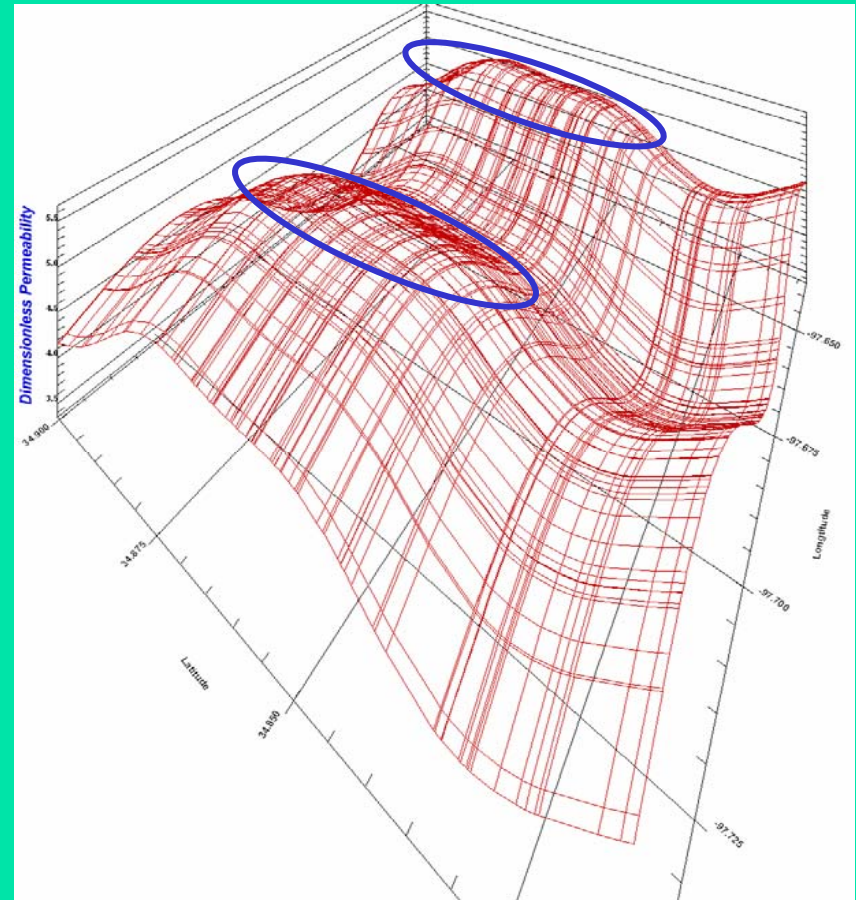
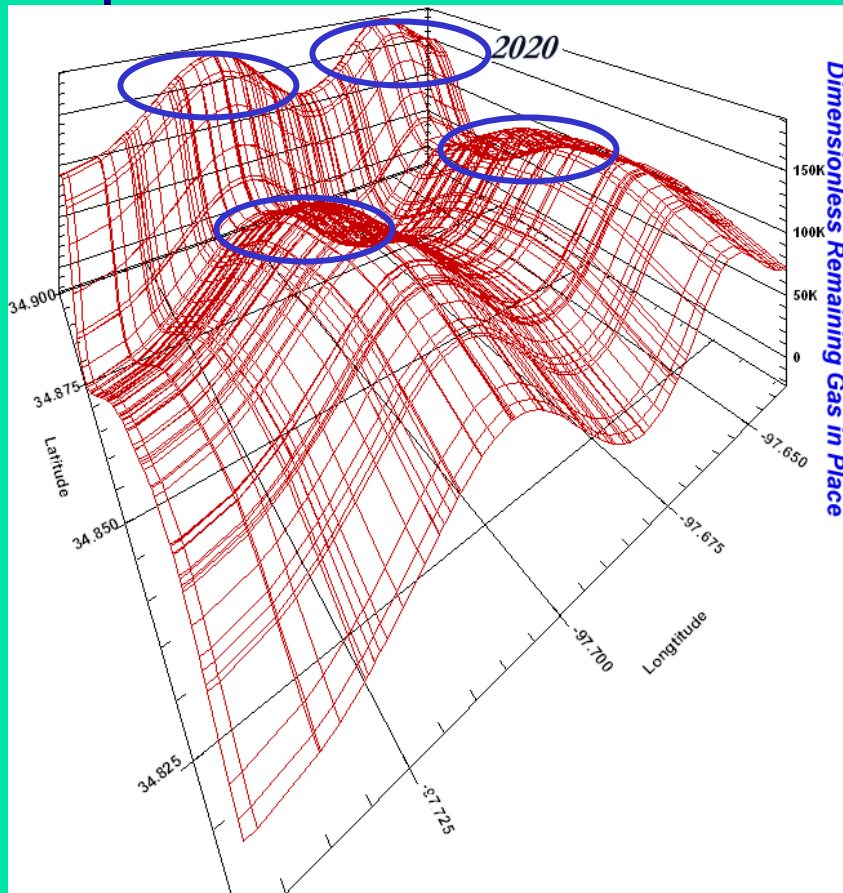


Remaining Reserves



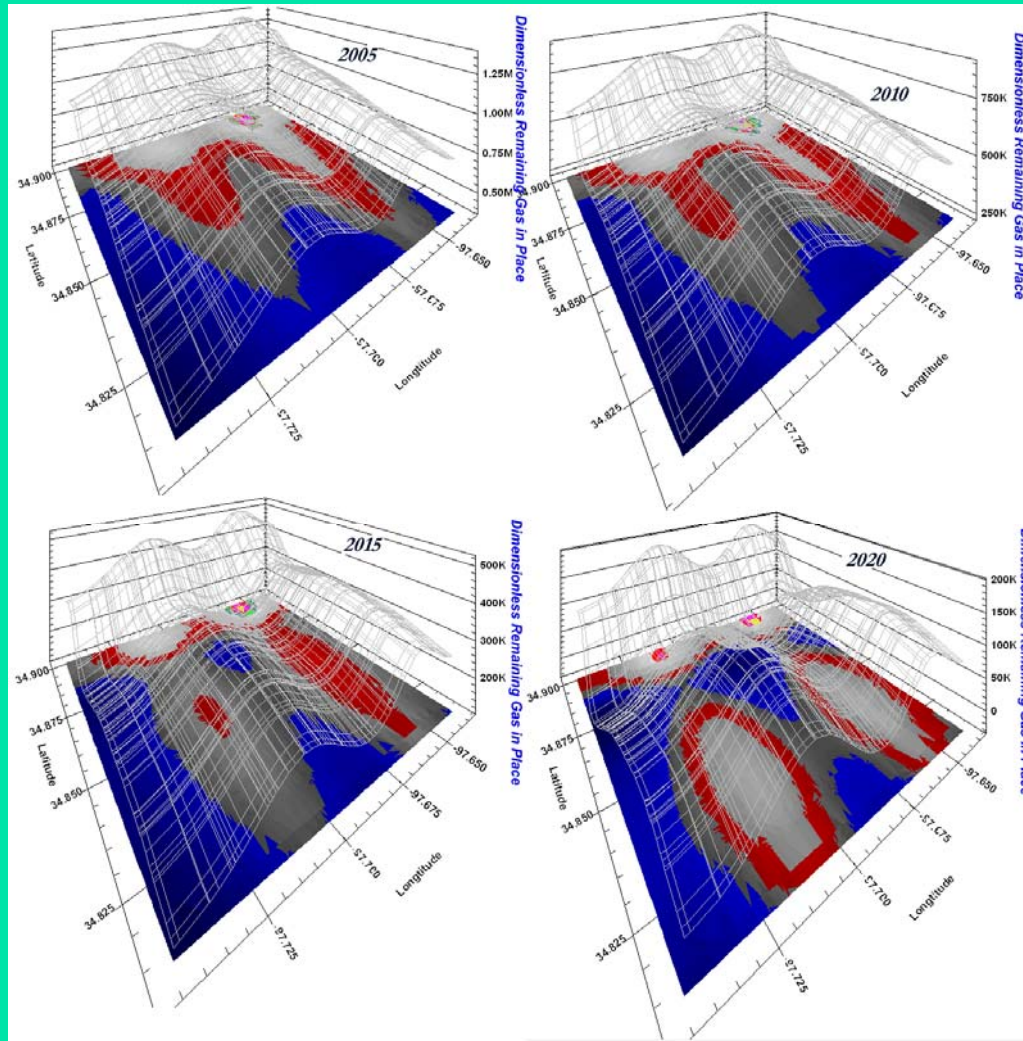


Sweet Spots





Remaining Reserves



Using this result and performing some **What-If** scenarios, one may identify the best location for in-fill drilling.