Petrophysical Characterization of a Lower Cretaceous Carbonate Reservoir, Onshore Abu Dhabi, UAE*

Suryanarayana Karri[1] and Yousef Al Mehairi[2]

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[1]Sproule International Limited, Calgary, AB, Canada. (suryak@sproule.com)
[2]Abu Dhabi Company for Onshore Oil Operations, Abu Dhabi, United Arab Emirates.

Abstract

A giant oil field onshore Abu Dhabi is a significant hydrocarbon producer from a Lower Cretaceous carbonate formation. Recently, a sequence stratigraphy framework was defined using extensive analysis of available core data and well log correlations. In addition, the study identified seven reservoir and three non-reservoir lithofacies and ten reservoir rock types. However, since the sequence stratigraphy study relied on core data, it could not address the issue of prediction of lithofacies and reservoir rock types in un-cored intervals.

Construction of a 3D geological model for the reservoir required the population of the grid cells with petrophysical properties such as porosity, permeability, and water saturation for a meaningful upscaled model for reservoir simulation. For the geological and the petrophysical models to be in consonance, it is imperative that both should honor the sequence stratigraphy framework. With this basic premise, a petrophysical model was constructed in parallel to the 3D geological model, with an emphasis on estimation of reservoir rock types and water saturation for a better control on the distribution of these parameters in the geological model.

The reservoir rock types were generated using lithofacies and flow zone indicators as the key parameters. The statistics show that the log-derived reservoir rock types are comparable to the core-defined reservoir rock types. Then, for each reservoir rock type, capillary pressure curves, saturation height functions, and Leverette-J functions from both core and log data were generated and were compared with the log-derived water saturation. It is shown that the log-derived saturation height functions replicated the water saturation profile better than the other methods. Examples are shown to demonstrate that the petrophysical model is realistic by honoring the sequence stratigraphy framework.

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Suryanarayana Karri, Sproule International Limited

Yousef Al Mehairi, ADCO

Presentation Outline

- Background
- Brief Geology
- Work Flow
  - Porosity and Water Saturation Estimation
  - Permeability Estimation
  - RRT Estimation
  - Saturation Modeling
- Conclusions

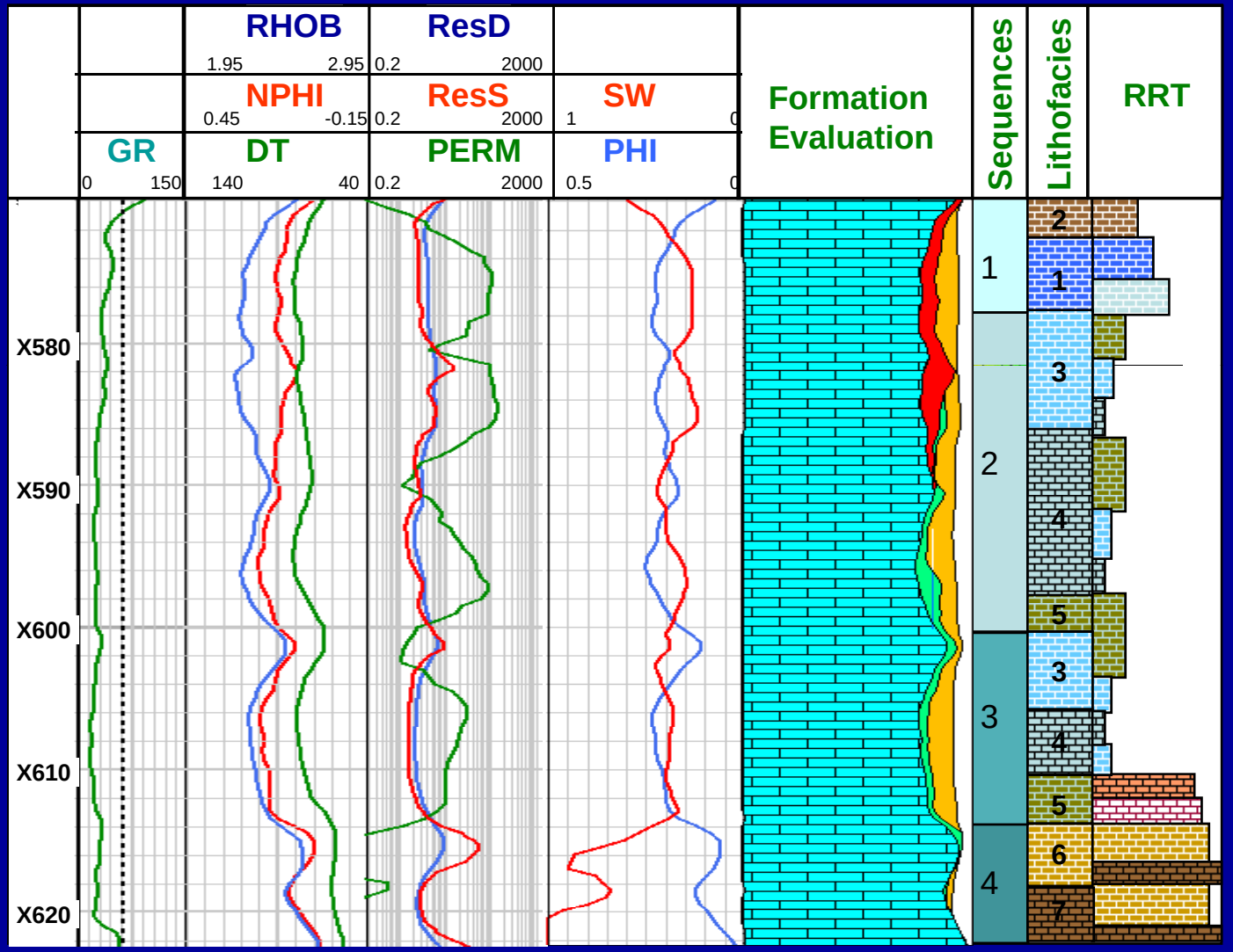
Background

- Rebuild 3D Geological Model
- Construct Reservoir Simulation Model
- Incorporate Additional Information
  - Additional Core Analysis
  - New Sequence Stratigraphic Study
  - Lithofacies Data
  - Rock Types

Geology

Field Location

Geology: Age, Structure and Type Log

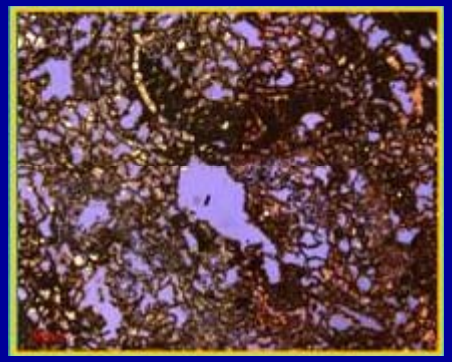


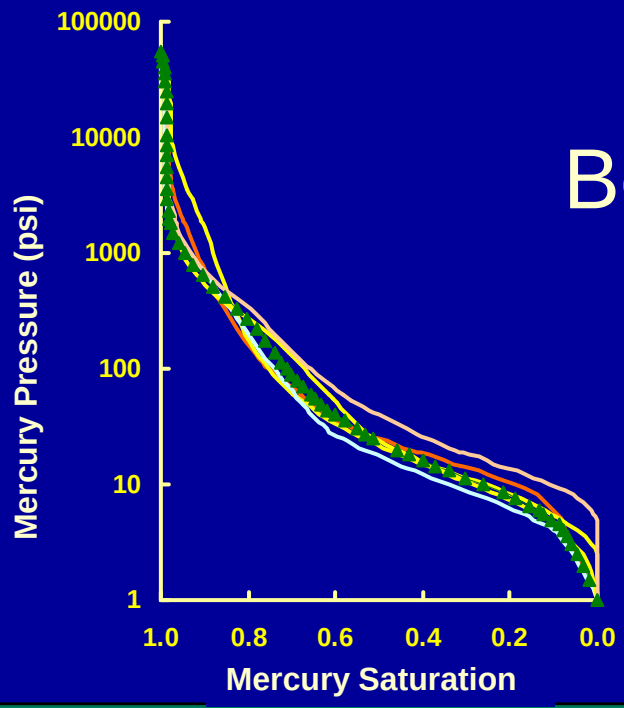
Sequence Stratigraphy to RRT

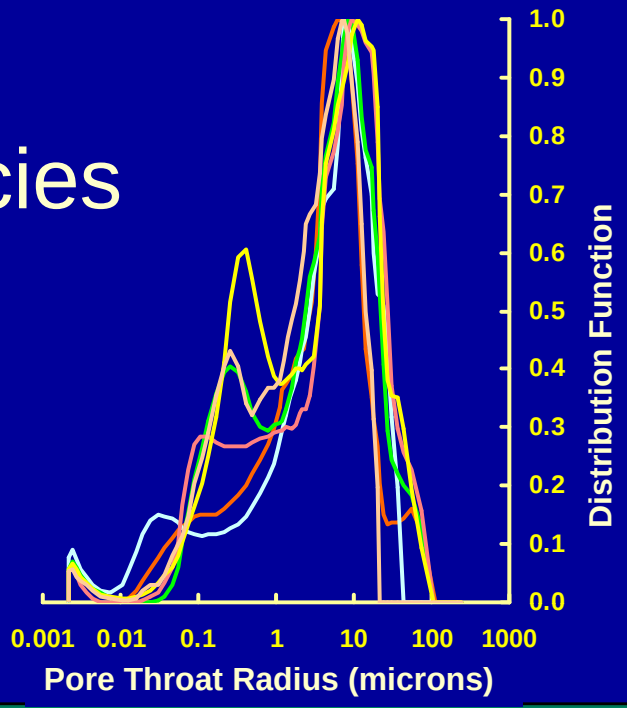
Sequence	Litho Facies	RRT	Porosity (%)	Permeability Range (mD)
1	2 (SPPG)	2	17	1-21
	1 (ASR)	3A	17	10-267
		3B	11	0-9
2	3 (BOB)	1A	24	90-544
		1B	22	7-90
		1C	17	1-7
	4 (OPFR)	1A	24	90-544
		1B	22	7-90
		1C	17	1-7
	5 (OPPF)	4A	19	1-64
		4B	15	0-1
3	3 (BOB)	1A	24	90-544
		1B	22	7-90
		1C	17	1-7
	4 (OPFR)	1A	24	90-544
		1B	22	7-90
		1C	17	1-7
	5 (OPPF)	4A	19	1-64
		4B	15	0-1
4	6 (AFEP)	5A	13	0-11
		5B	8	0-0.5
	7 (BSPP)	5A	13	0-11
		5B	8	0-0.5

Litho Facies	Description
1(ASR)	Algal Ball Skeletal Rudstone
2(SPPG)	Skeletal Peloid Packstone/ Grainstone
3(BOB)	Bacinella Oncoid Boundstone
4(OPFR)	Oncoid Peloid Floatstone/ Rudstone
5(OPPF)	Oncoid Peloid Packstone Floatstone
6(AFEP)	Algal Foraminifera Econoid Packstone
7(BSPP)	Bioturbated Skeletal Peloid Packstone

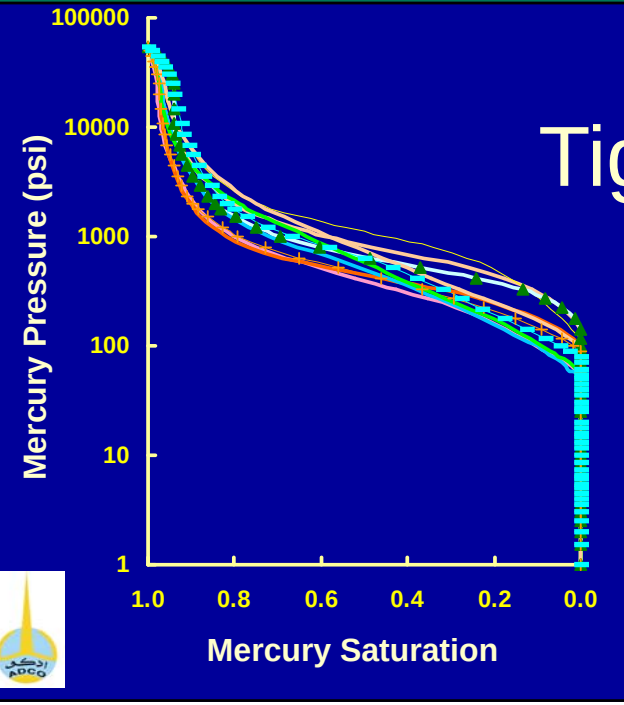
OPFR
Better Lithofacies

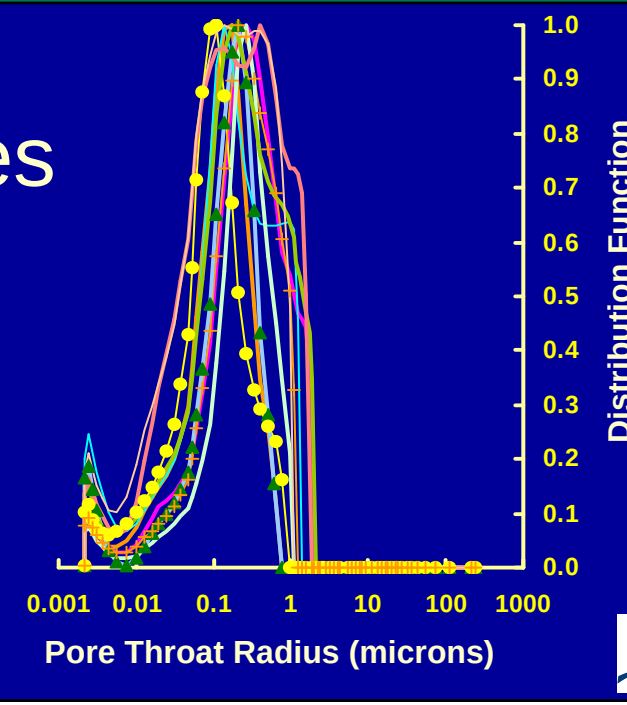






BSSP
Tight Lithofacies

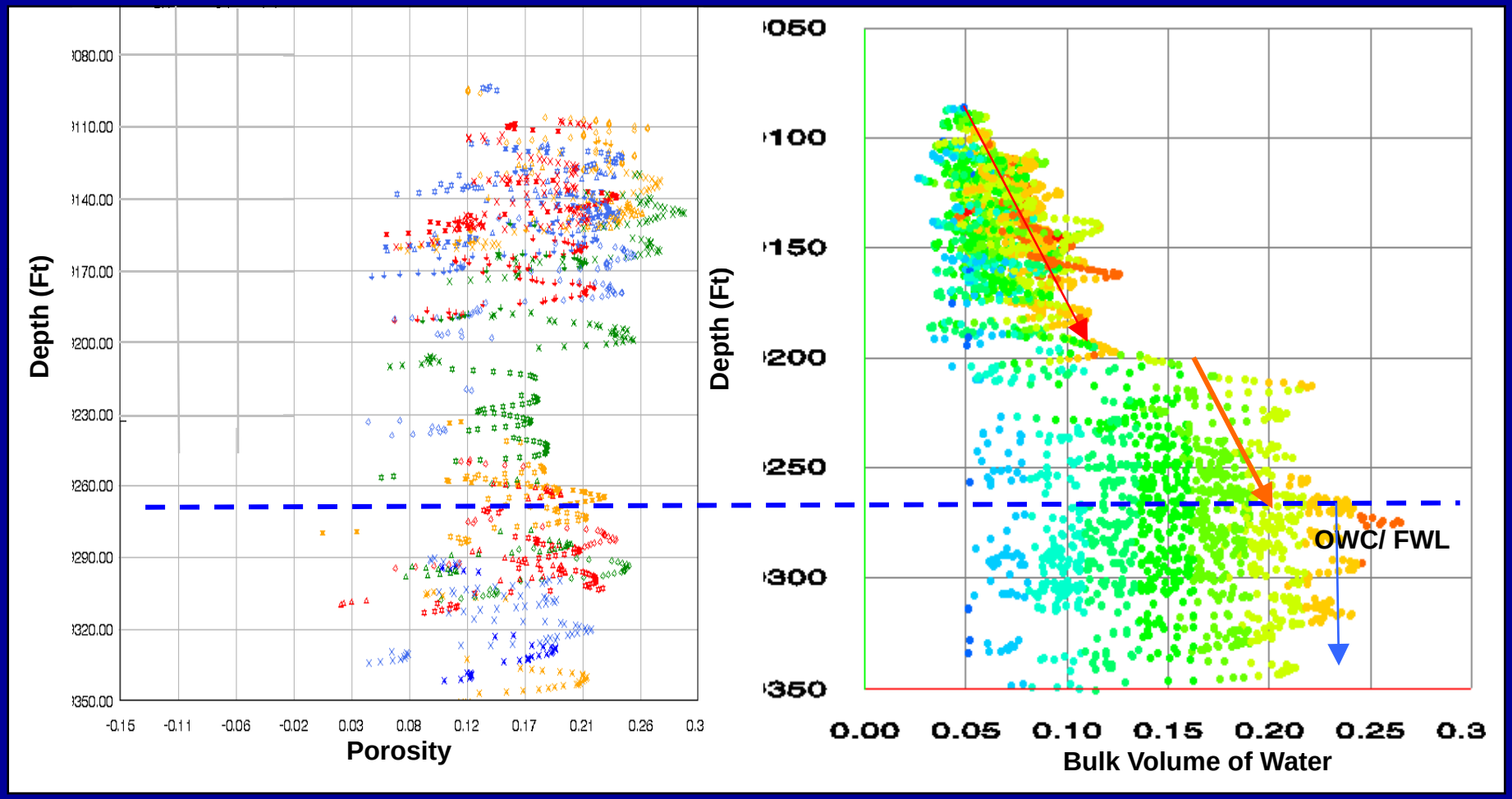




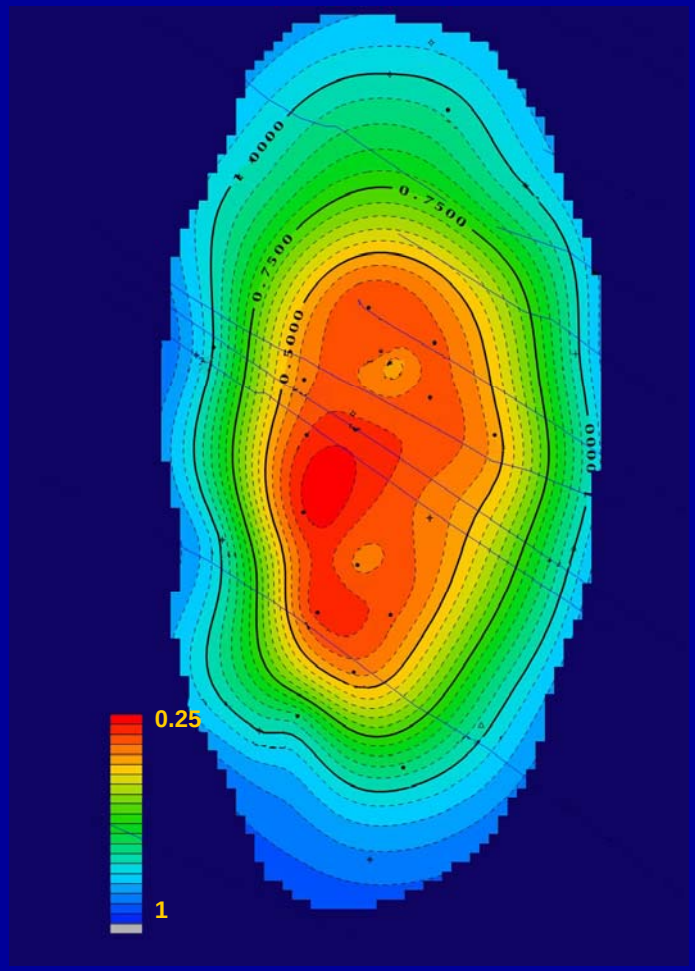
Porosity and Water Saturation

ELAN

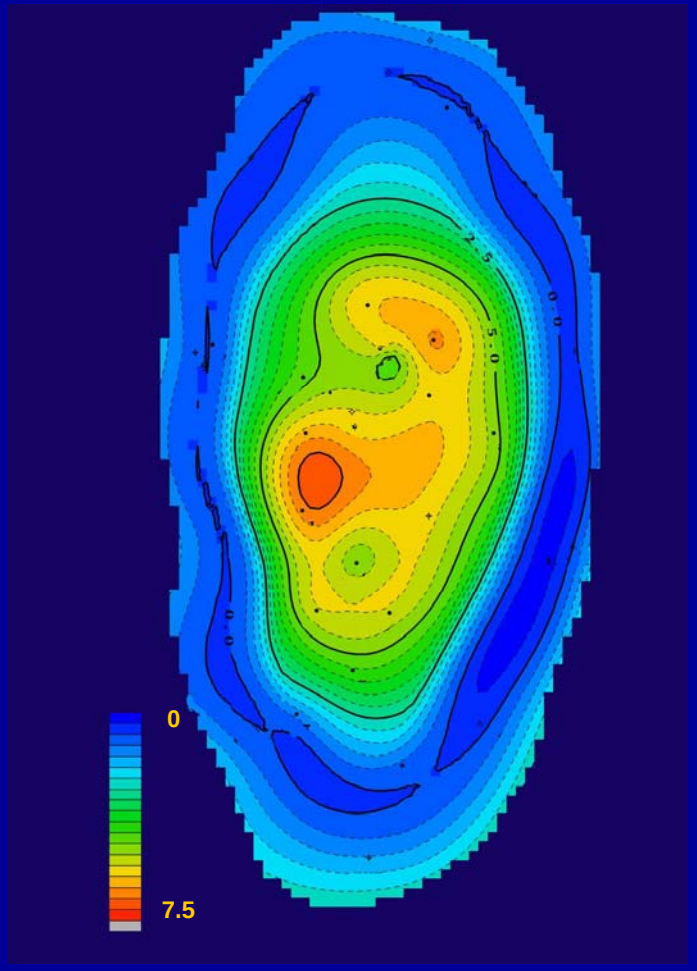
Porosity and BVW Interpretation



Hydrocarbon Pore Volume



Water Saturation

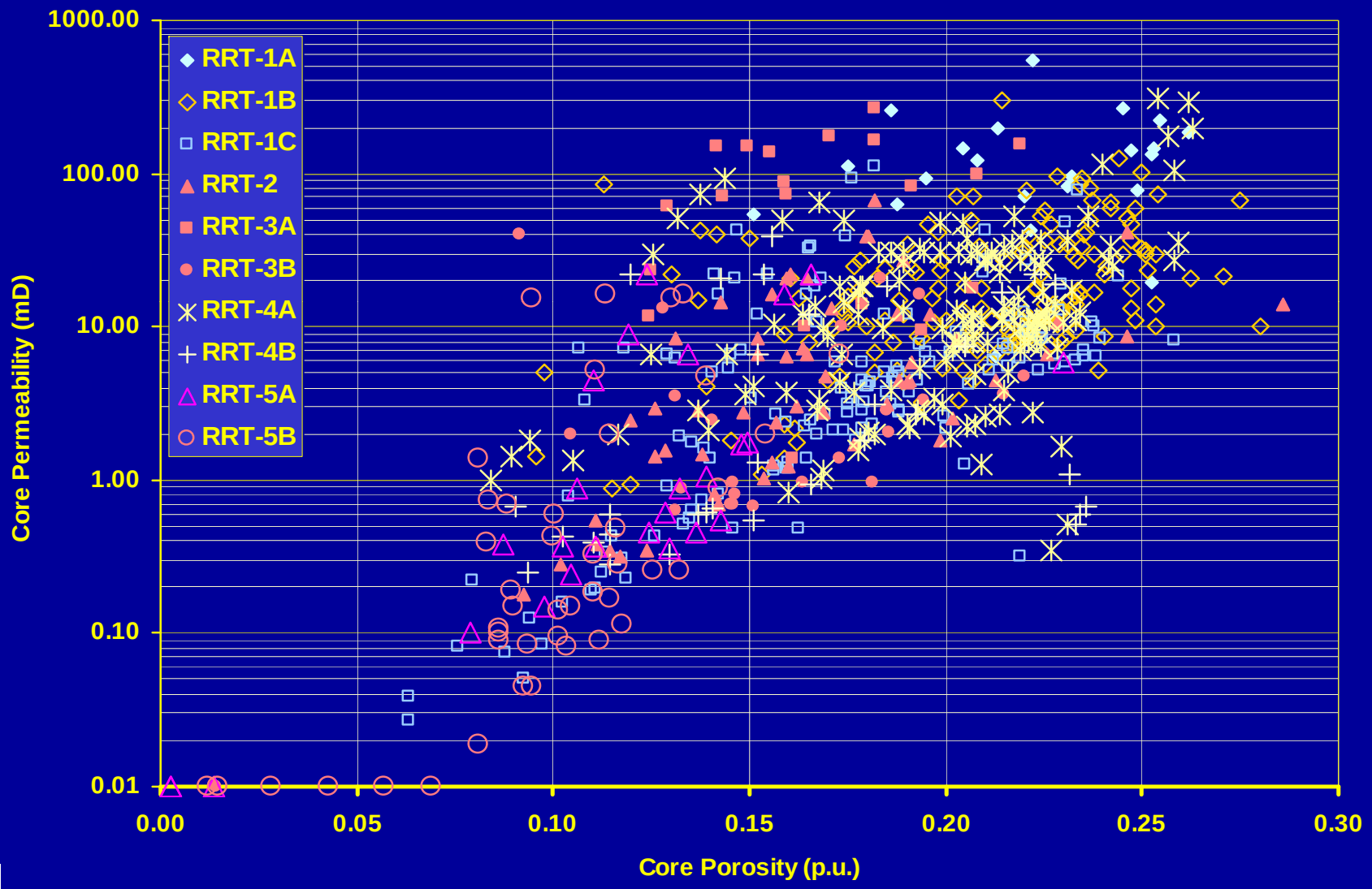


Hydrocarbon Pore Volume

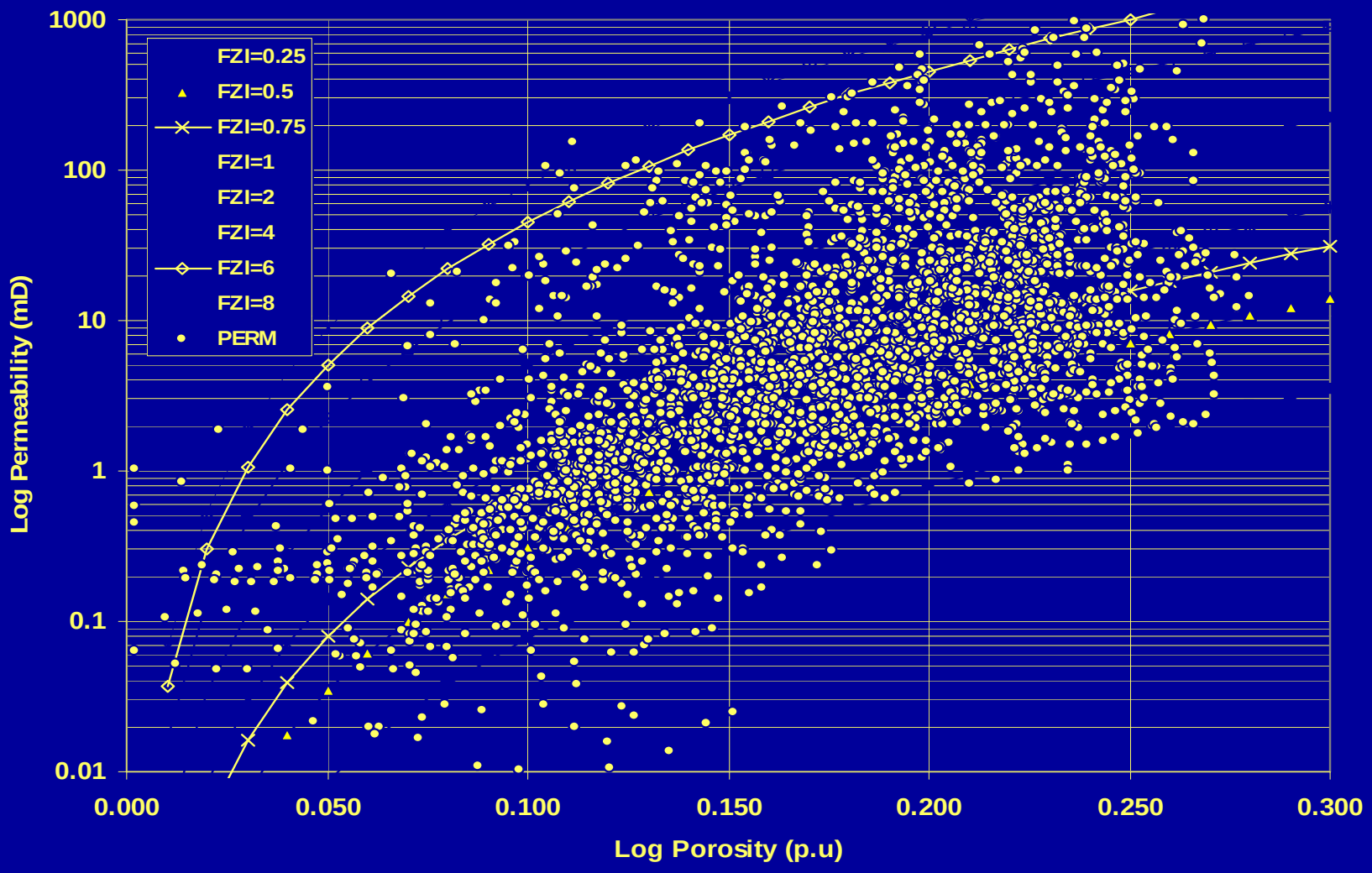
Permeability Estimation

Neural Network Method

Core Poro-Perm Plot



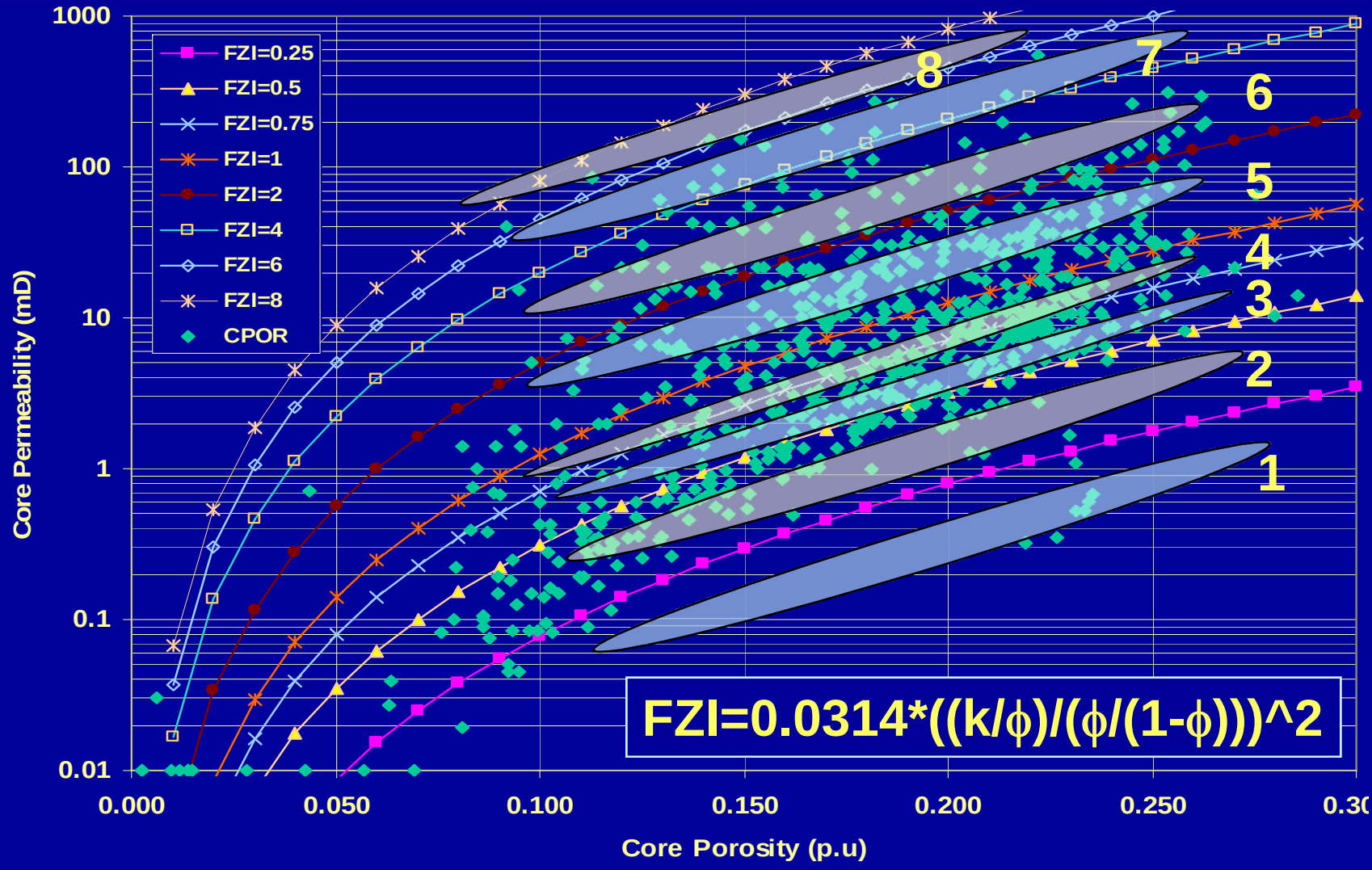
Log Poro-Perm Plot



Reservoir Rock Typing

Based on Flow Zone Index

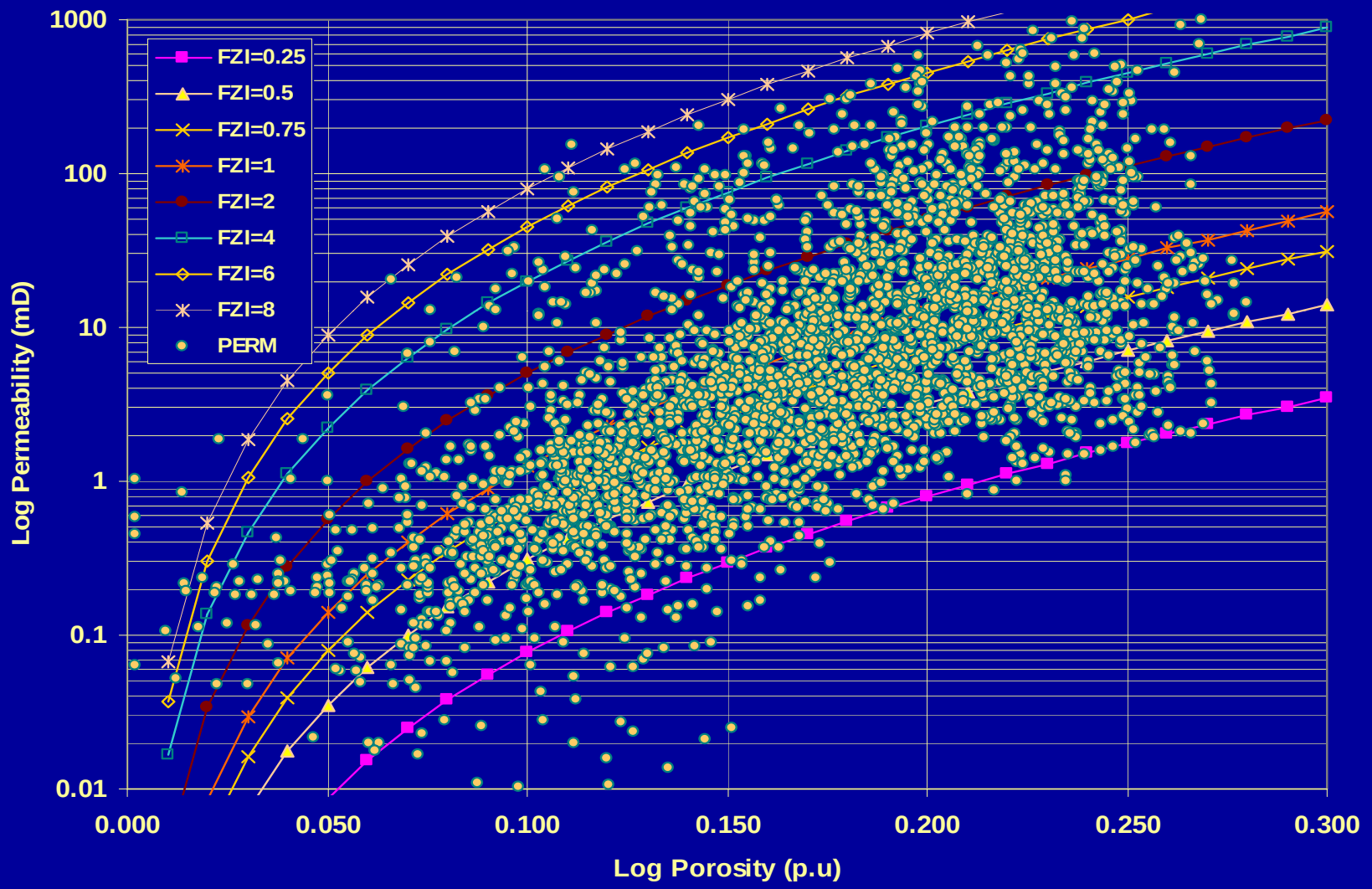
SCAL Flow Zone Index



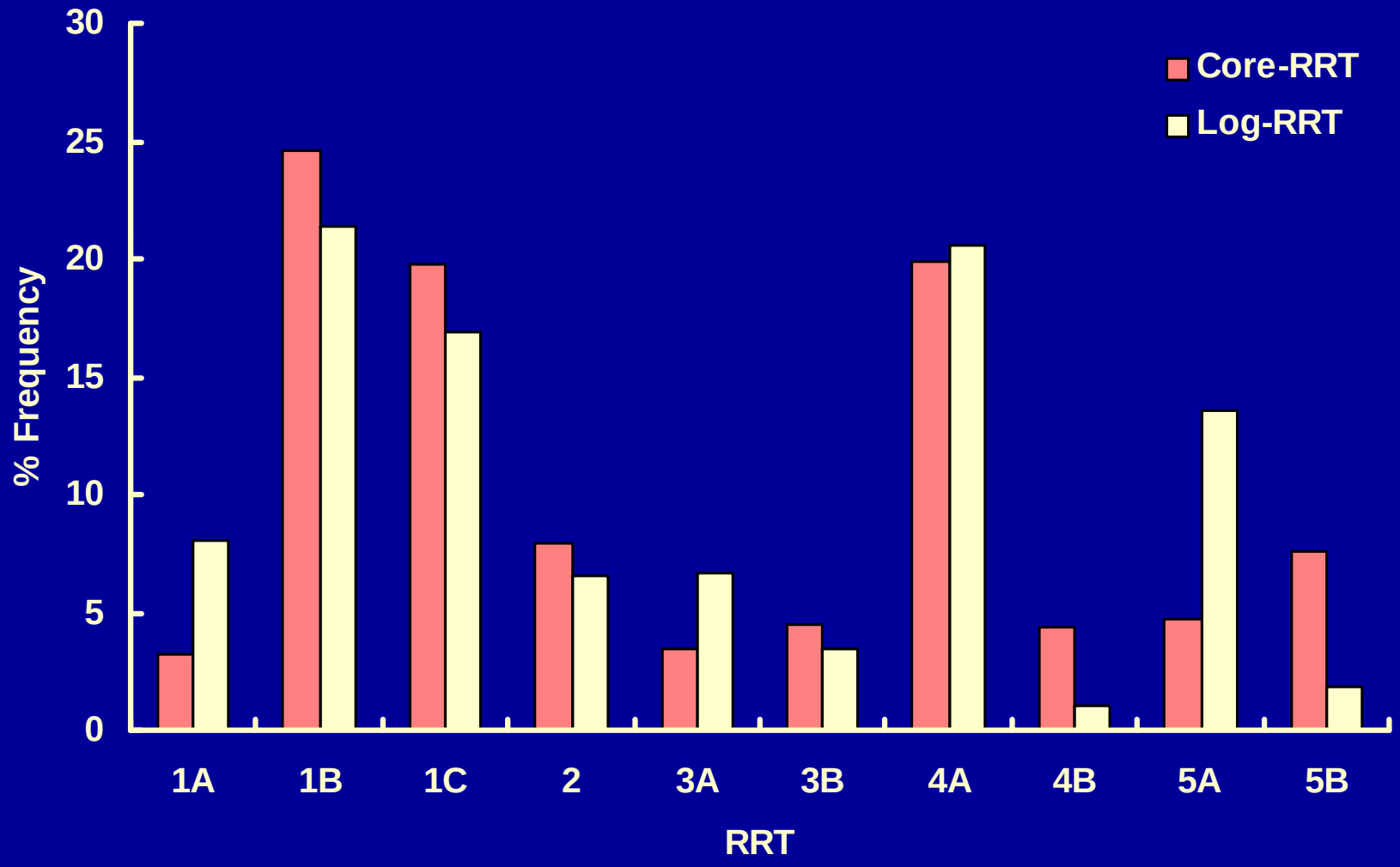
Flow Zone Index End Points

RRT	RRT-Code	FZI (SCAL)	
		Min	Max
1A	11	2.14	3.3
1B	12	0.33	2.18
1C	13	0.29	0.79
2	14	0.03	0.54
3A	15	2.1	5.88
3B	16	0.21	1.18
4A	17	0.42	1.5
4B	18	0.27	0.43
5A	19	0.42	1.18
5B	20	0.16	1.07

Reservoir Rock Typing Using FZI



RRT Statistics



Saturation Modeling

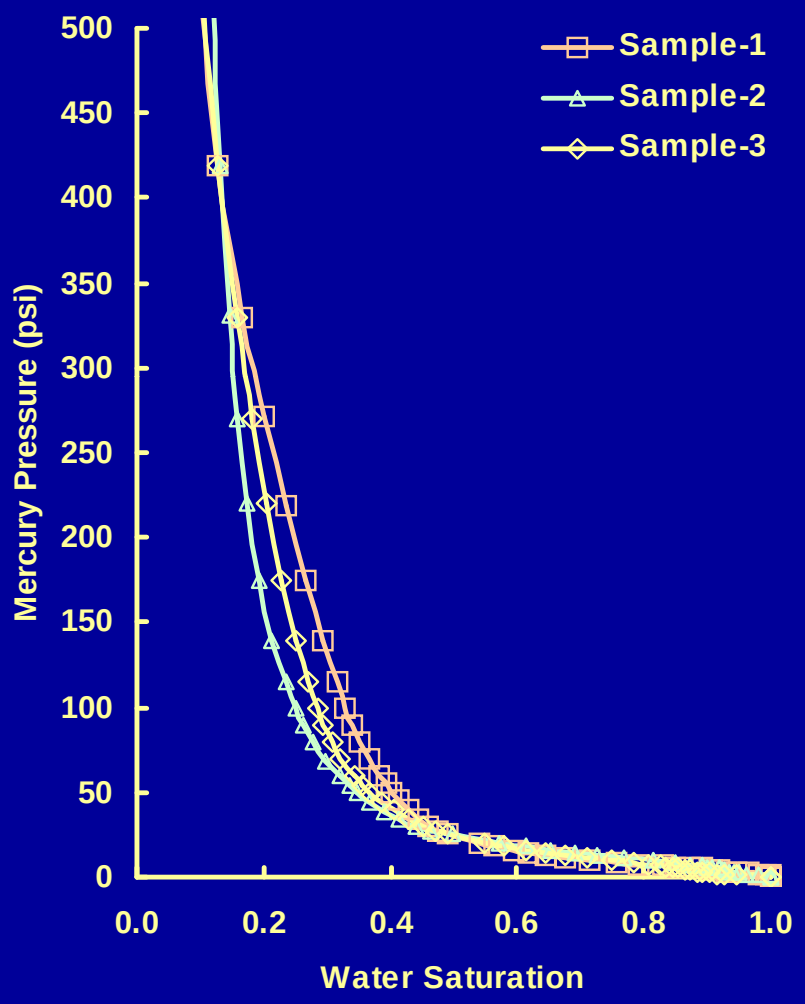
Using core and log data

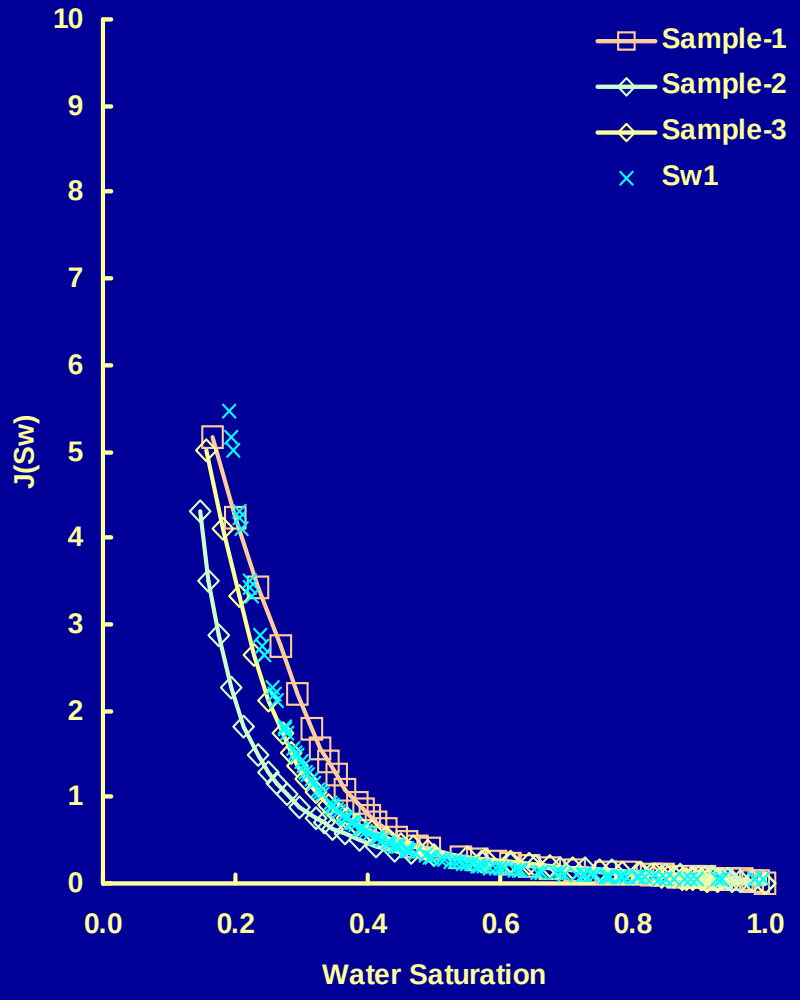
Generic Curve-Fit Equation

$$Y=AX^{B}$$

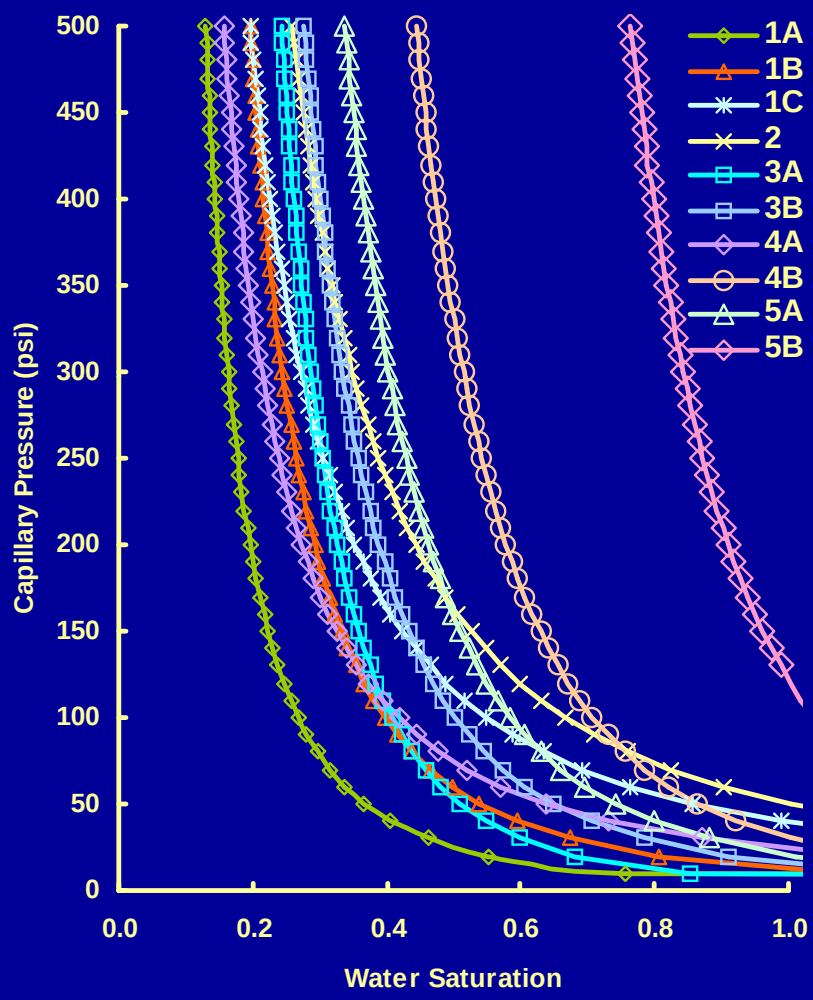
- Y is Water Saturation
- X can be
  - Capillary Pressure (Core)
  - J Function (Core, Log)
  - Height above FWL (Log)
- A and B are coefficients regressed for appropriate function

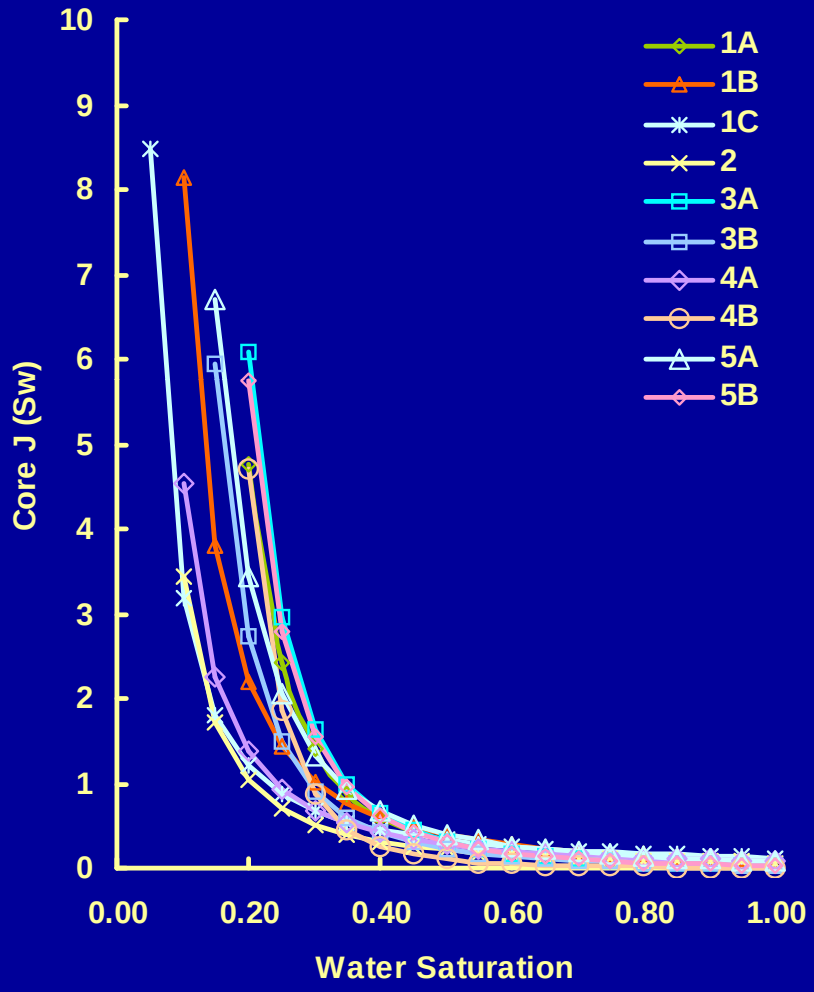
Example Curve-fit of Core Data for a RRT



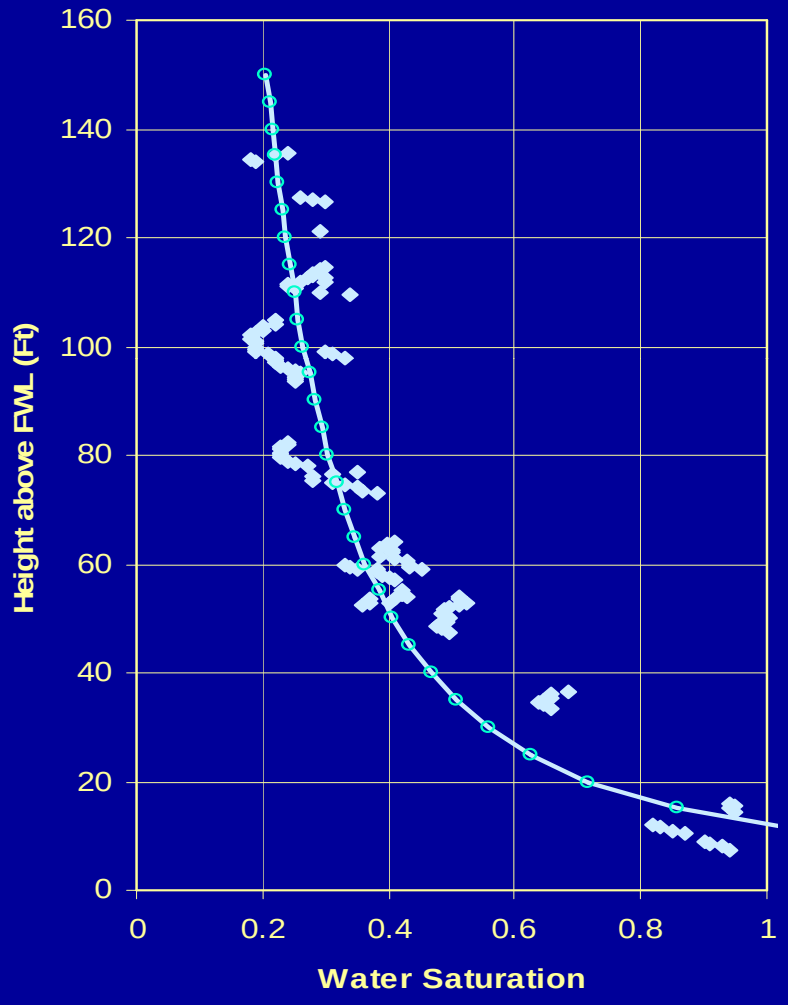


Core Pc and J Functions for all RRTs

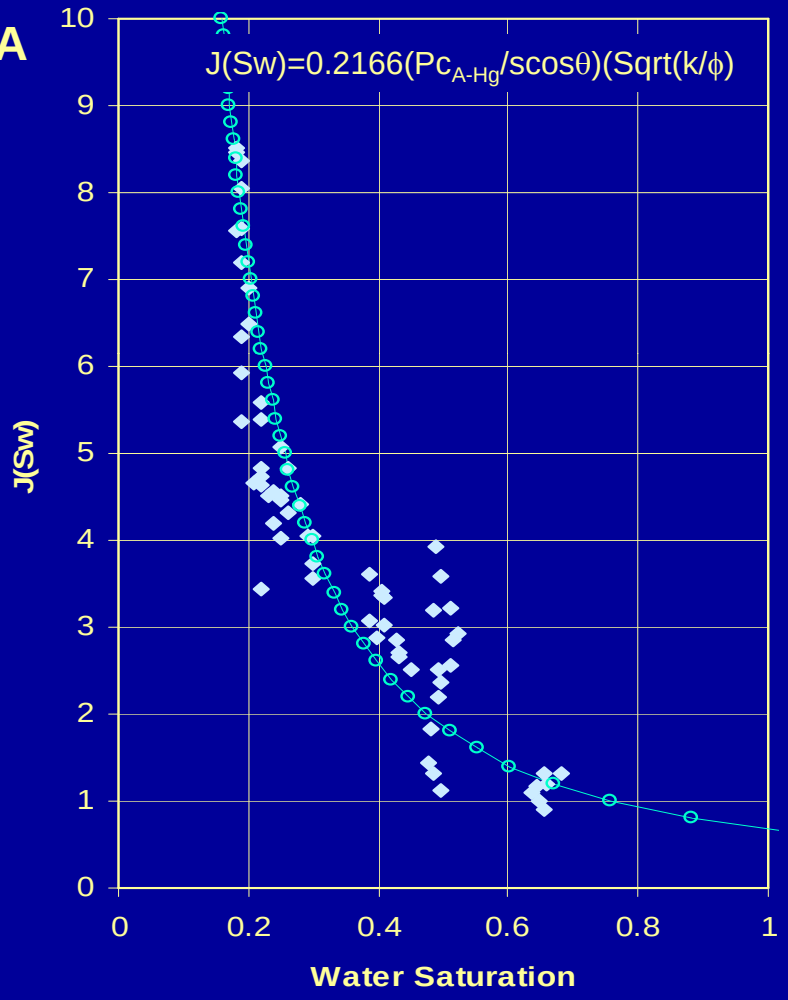




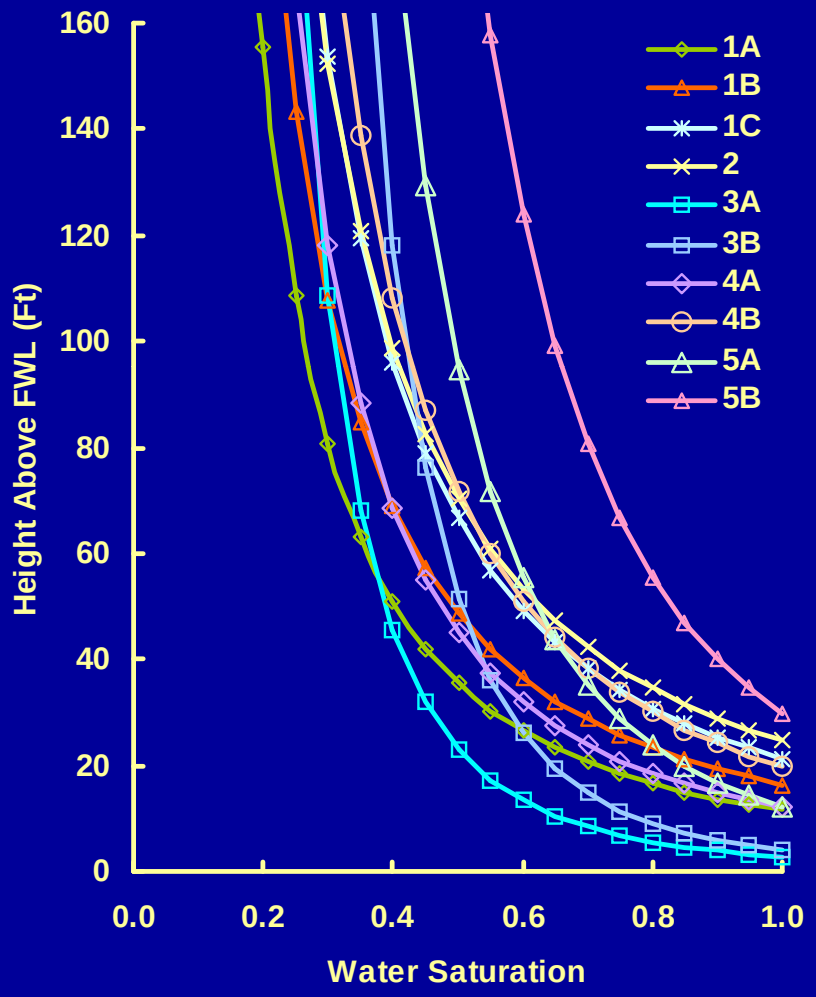
Example Log Data Curve-fit for a RRT

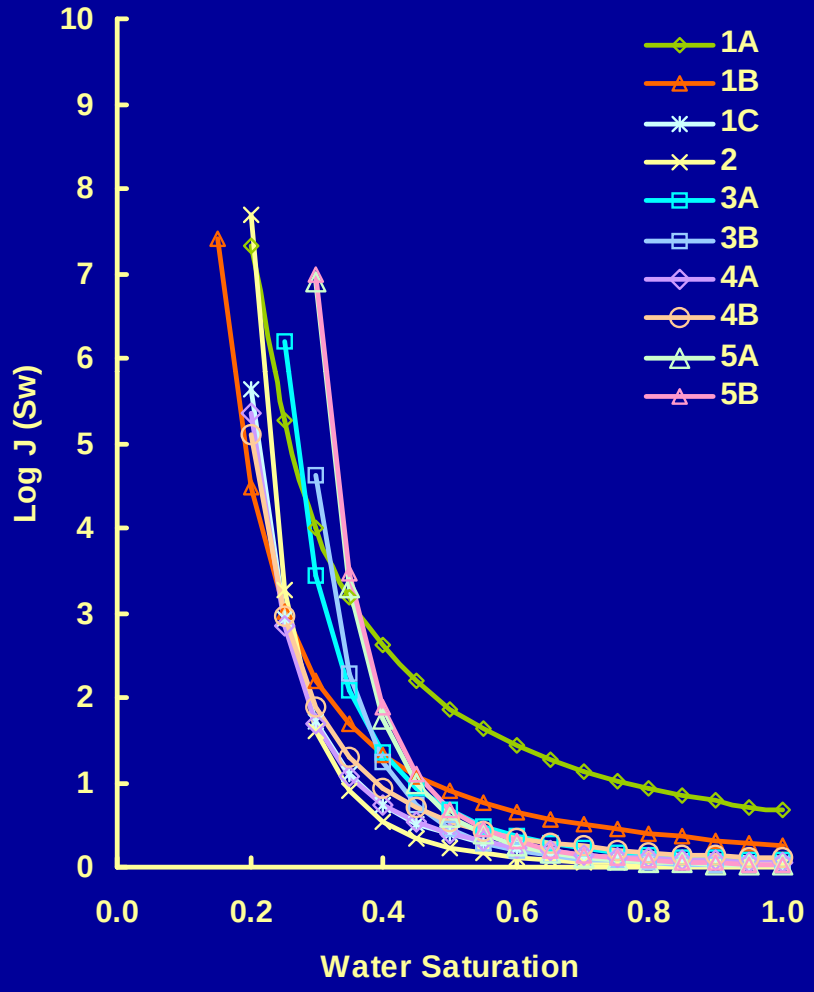


RRT-1A

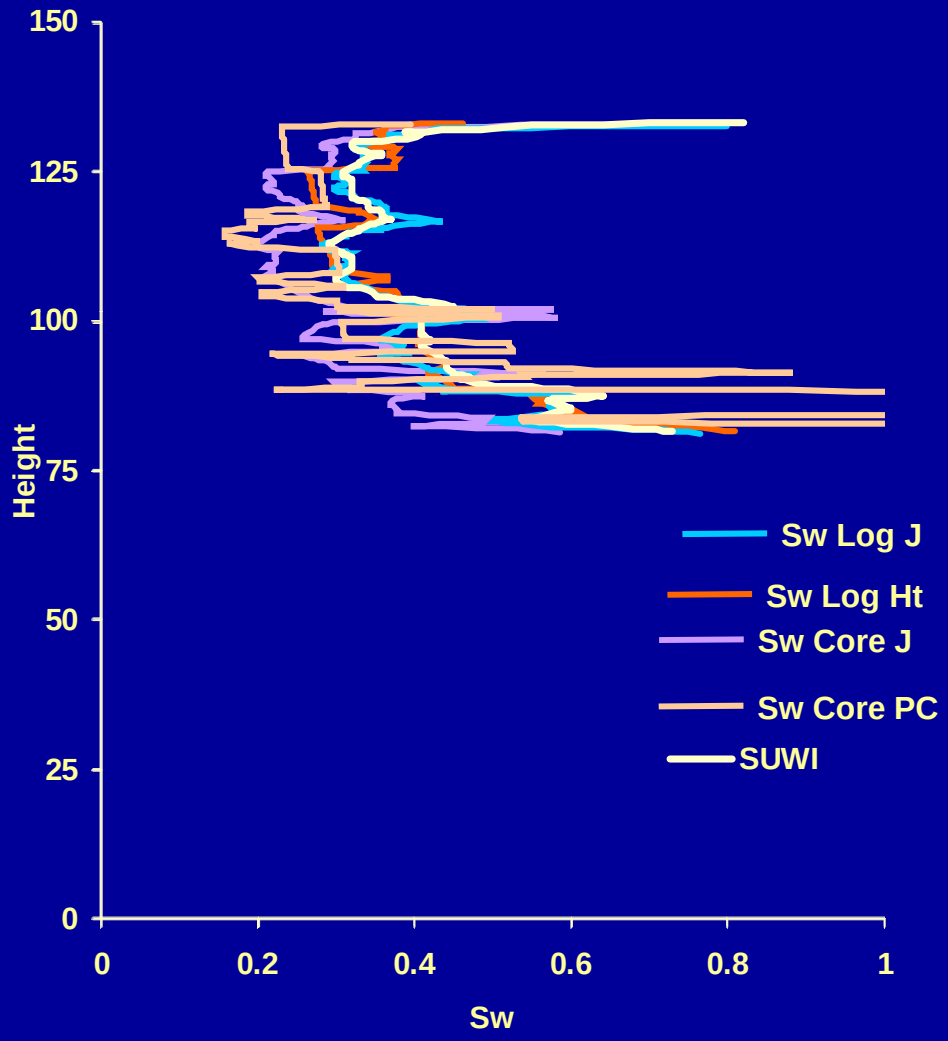


Height and J Functions for all RRTs





Comparison of Water Saturation: An Example



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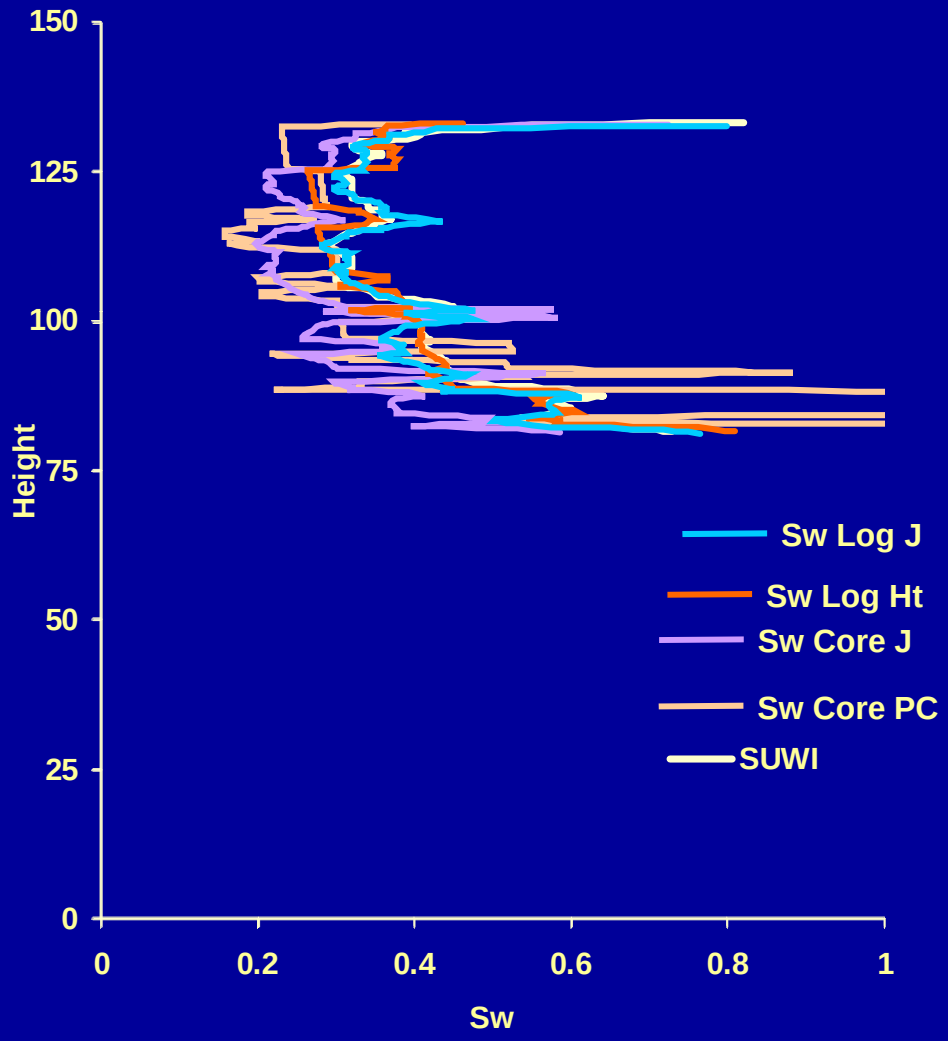
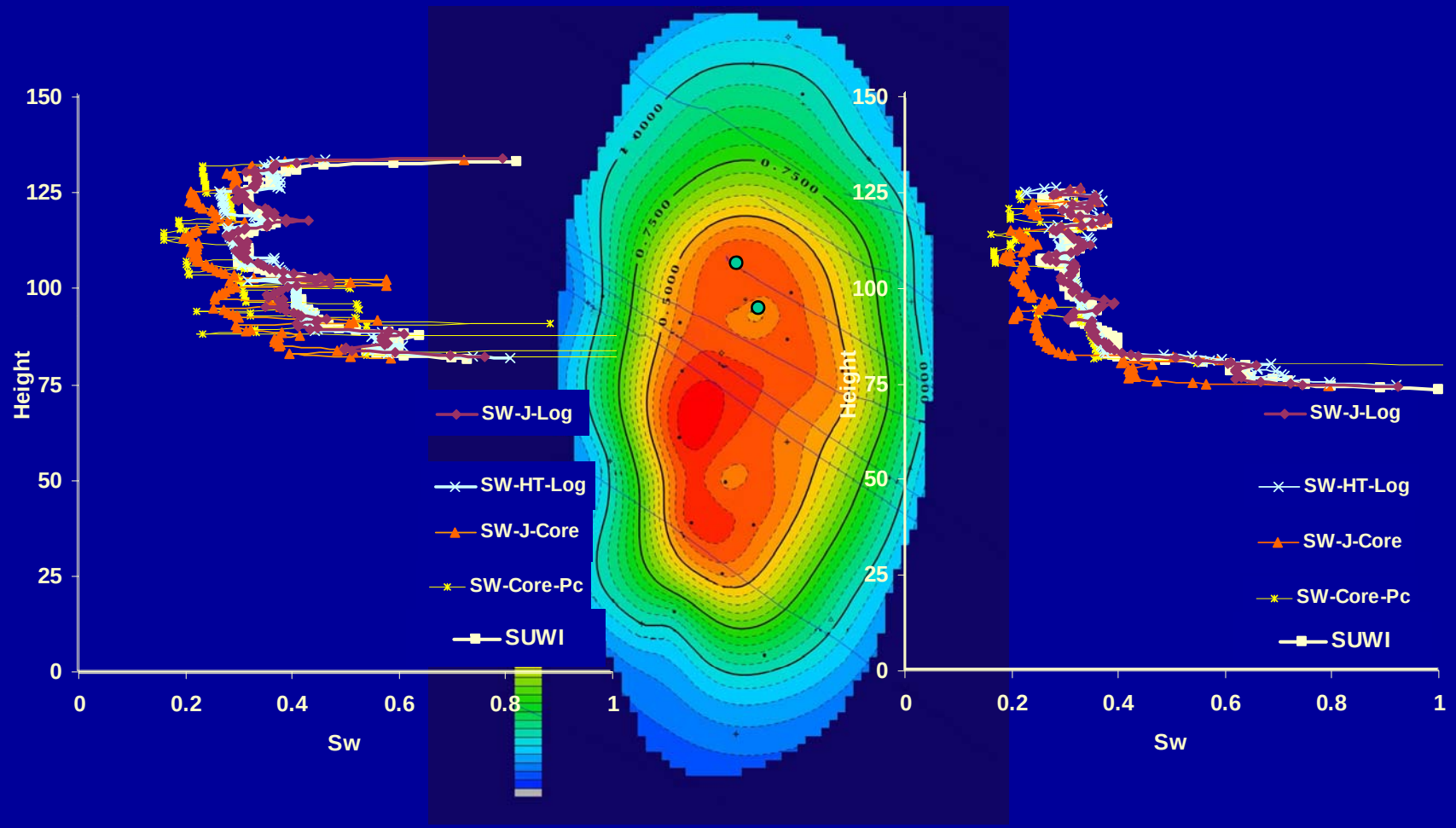


Conclusions

- Consistent Petrophysical Model
  - Porosity and Water Saturation
- Sequence -> Litho -> RRT
- Rigorous Saturation Modeling
  - Core Pc, Log Height Functions, J Functions
- Complete Petrophysics for 3D model
  - Lead to a better simulation model

Thank You

Comparison of Water Saturations



Log Derived J Functions Better Match Log Saturations

Tongue Twisters

Litho Facies	Description
1(ASR)	Algal Ball Skeletal Rudstone
2(SPPG)	Skeletal Peloid Packstone/ Grainstone
3(BOB)	Bacinella Oncoid Boundstone
4(OPFR)	Oncoid Peloid Floatstone/ Rudstone
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