Advance Facies Rock Typing Approach for 3D Geocellular Static Modeling for Polymer Flooding in the Tambaredjo Oil Field, Suriname*

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Abstract

The Tambaredjo (TAM) oilfield is located in the marshy coastal area in the district of Saramacca, Suriname. The reservoirs in the TAM field are part of the unconsolidated Paleocene sands, the so-called T-sands (T1, T2, and T3 units at 900-1400ft depths), on lapping against the 1-2 degree sloping top of the Cretaceous unconformity. The T-Unit is very erratically deposited in an upper to lower delta plain with braided to meandering fluvial channels with shallow marine influences. This shallow field produces a medium-heavy oil (~ 16 °API gravity) with a reservoir viscosity of around 600 cP. Production commenced in 1982 and has peaked to nearly 17,500 BOPD, through drilling of over 2,000 production wells. Apparent production decline, increasing water cuts, and depleting pressure in this field, justify the need for secondary and tertiary recovery techniques. Based on common screening criteria, part of the field is suitable for polymer flooding. Staatsolie initiated a pilot polymer flood project in September 2008 after simulations with a 3D geocellular model built with sand and no sand lithofacies approach. Forecasts resulting from dynamic modeling compared to the pilot results seemed pessimistic and unreliable due to uncertainties related to the lithofacies approach. High reservoir heterogeneity and lacking laboratory measurements for dynamic properties related to the lithofacies, resulted in inflow issues in the dynamic simulation model. A new sedimentological approach for 3D geocellular static modeling based on Rock Typing (RT) opposed to the conventional lithofacies modeling appears to capture the flow characteristics within the reservoir, since several flow units can be present in a single lithofacies. The Winland-Pittman method is based on an empirical equation relating porosity (storage capacity) and permeability (flow capacity) to a pore throat radius (PTR), which is used to tackle the facies issue. Based on this calculation the T-Unit reservoirs can be subdivided into 6 (six) flow units (rock facies). RT fraction maps were then used to guide stochastic trend and facies modeling processes. All property distributions (e.g. porosity, permeability, and water saturation) were conditioned to the Rock Type ‘facies’. Based on the PTR, the rock types could be linked to the flow properties. This major change in modeling, better suits the end purpose of the static model: to provide a robust and accurate simulation flow model to predict polymer injection and its production response in the certain part of the TAM oilfield.

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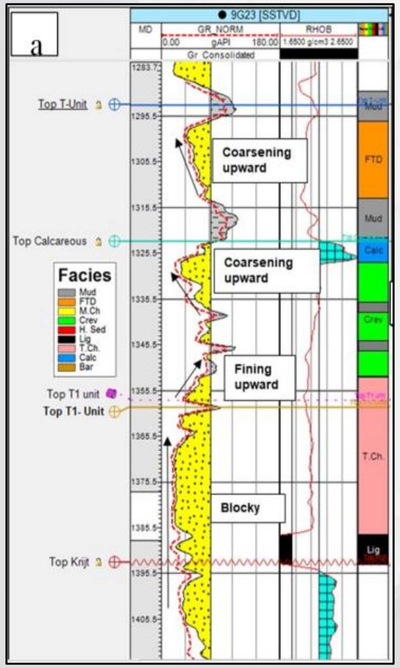

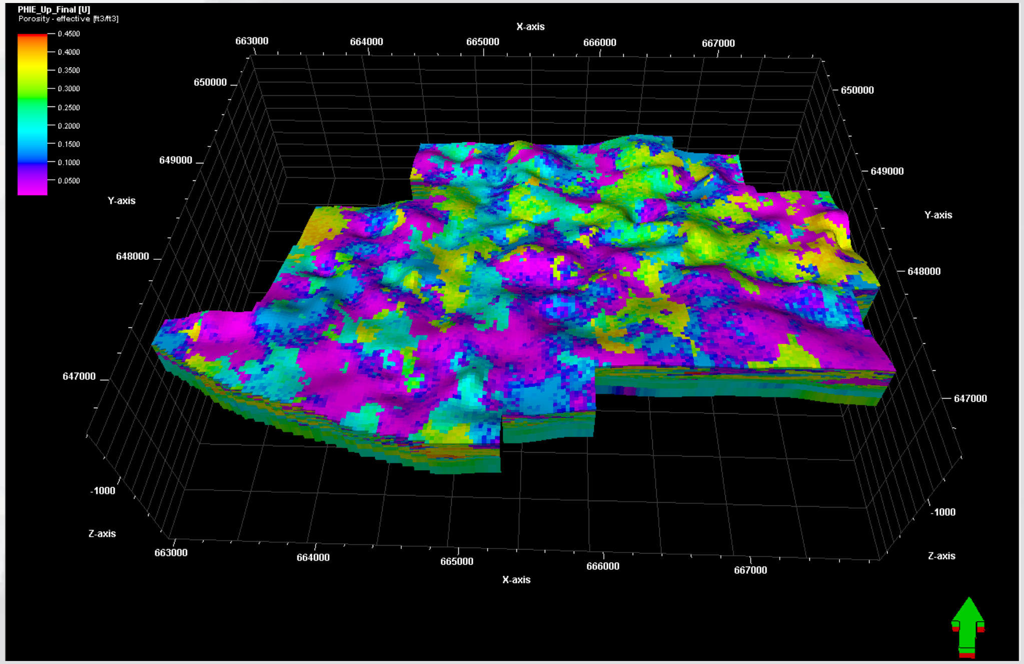

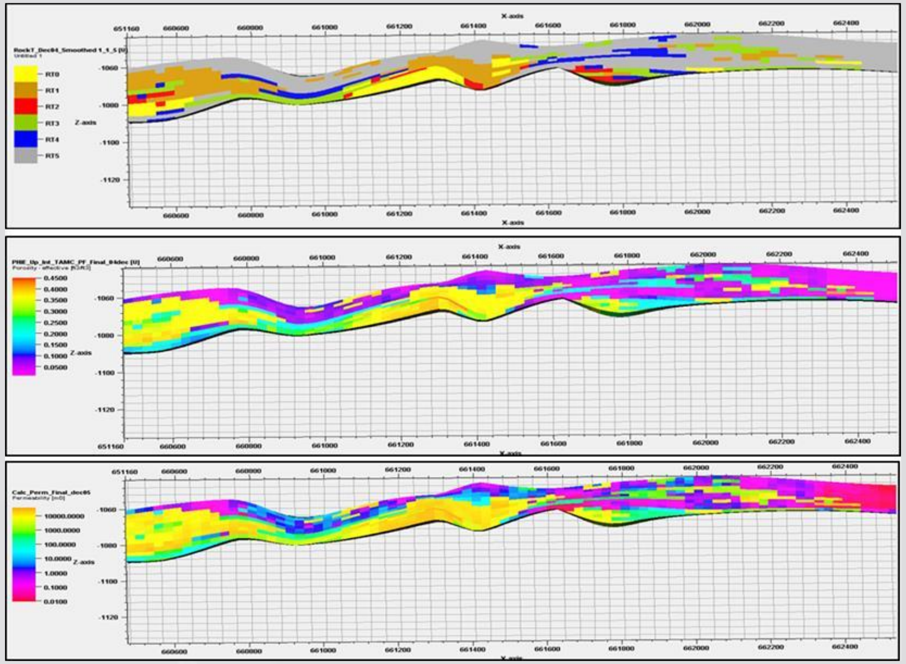

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Agenda

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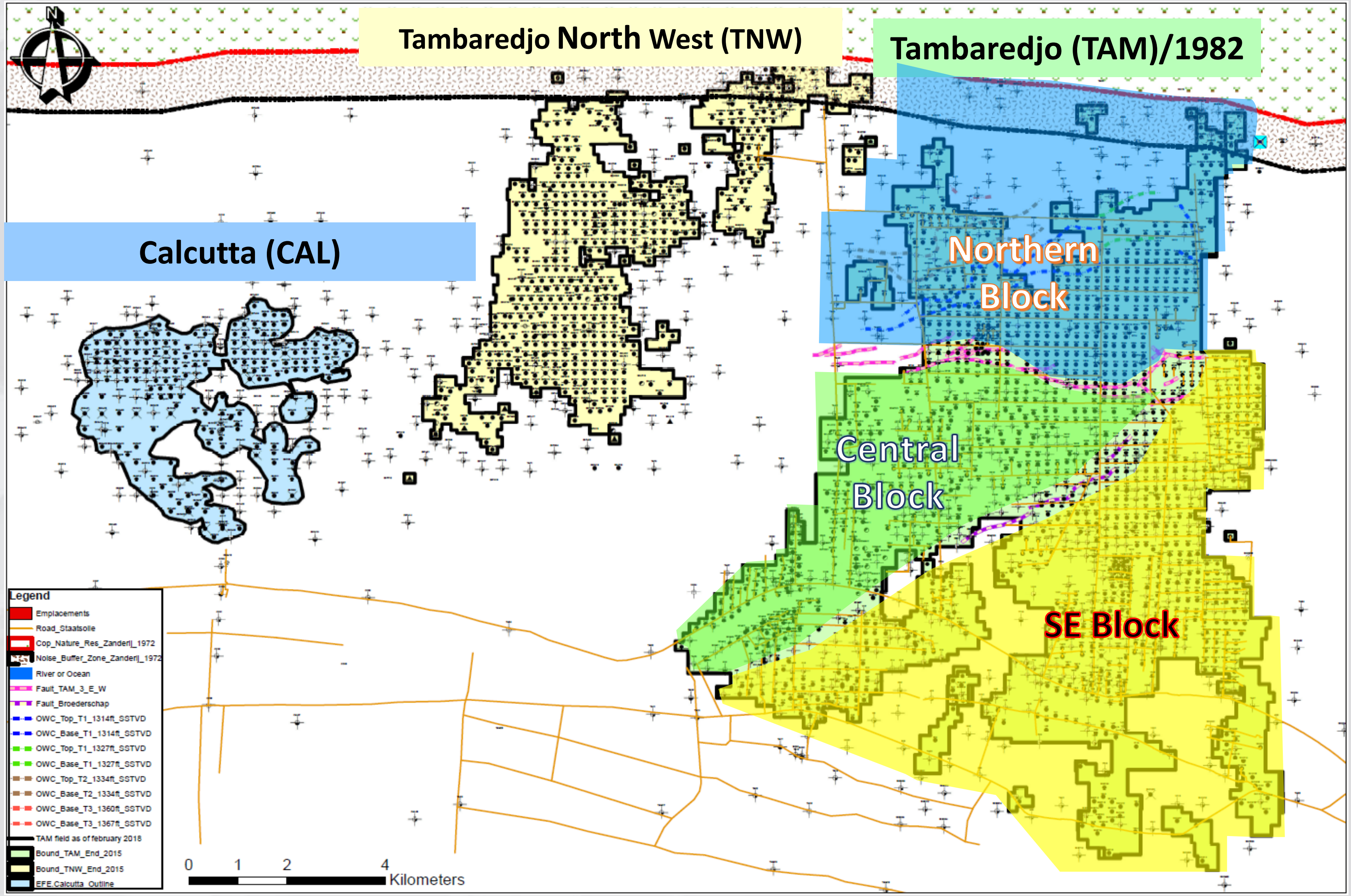
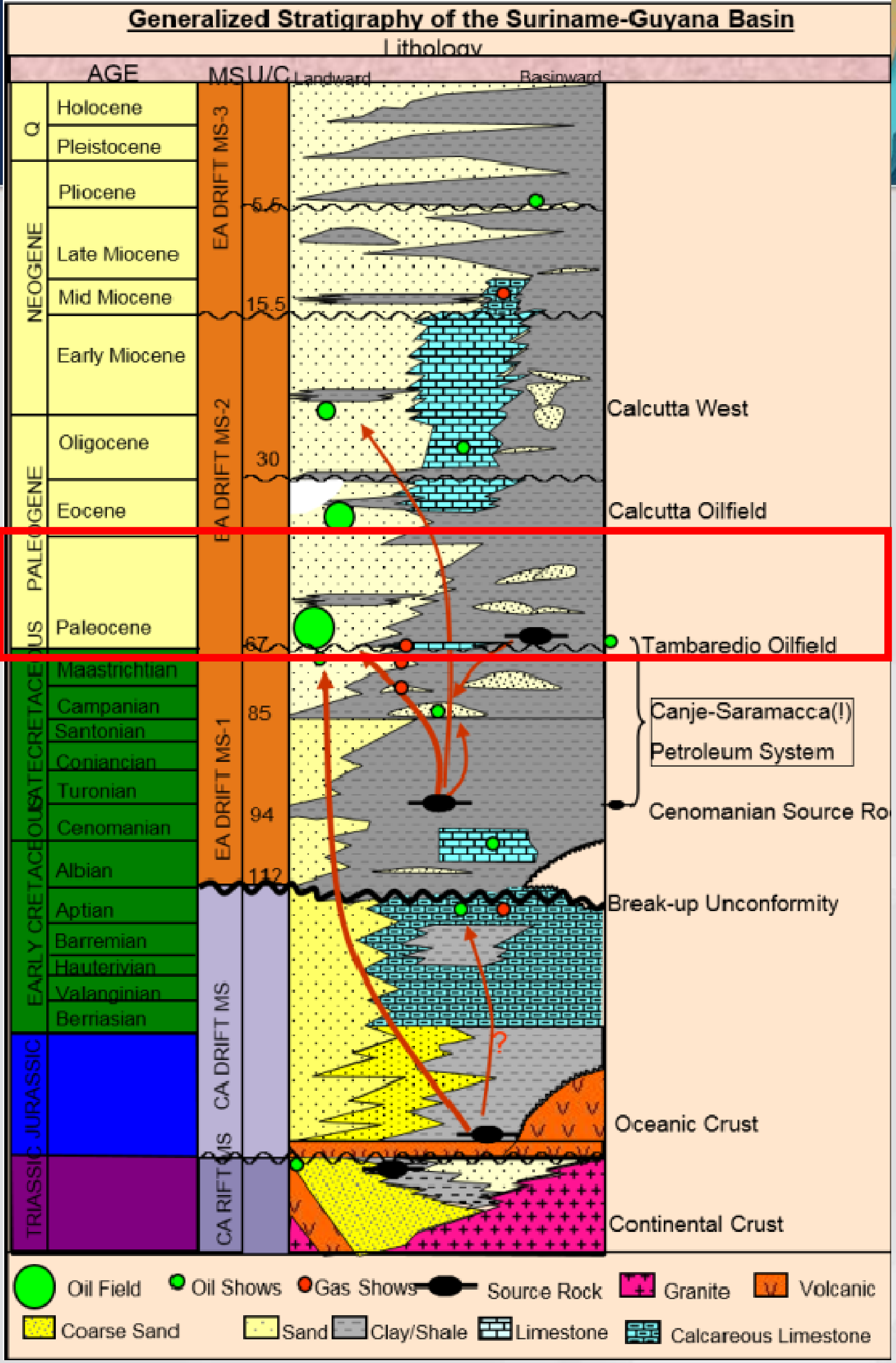
General overview TAM field

General information	
Producing wells	1221
Production	16500 bopd
Shallow Depth	250-450 m
Reservoir rock	Unconsolidated sands
Seal	Clay/Calcareous
Net thickness	1.5-15 m
Porosity	33-40%
Permeability	0.5-40 D
Pressure	400-500 psig
Heavy Oil	16-17 API
Oil Viscosity	400-600cp @100 F





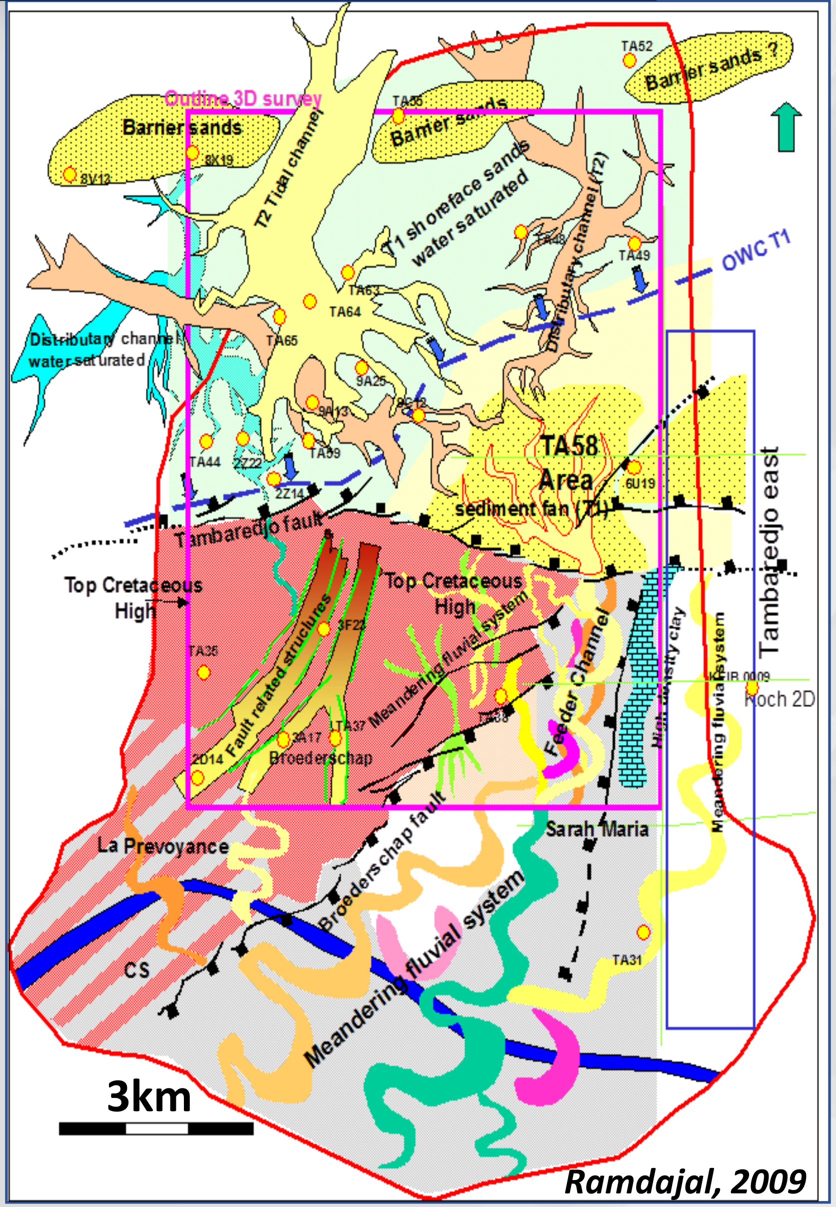
Stratigraphy Tambaredjo field

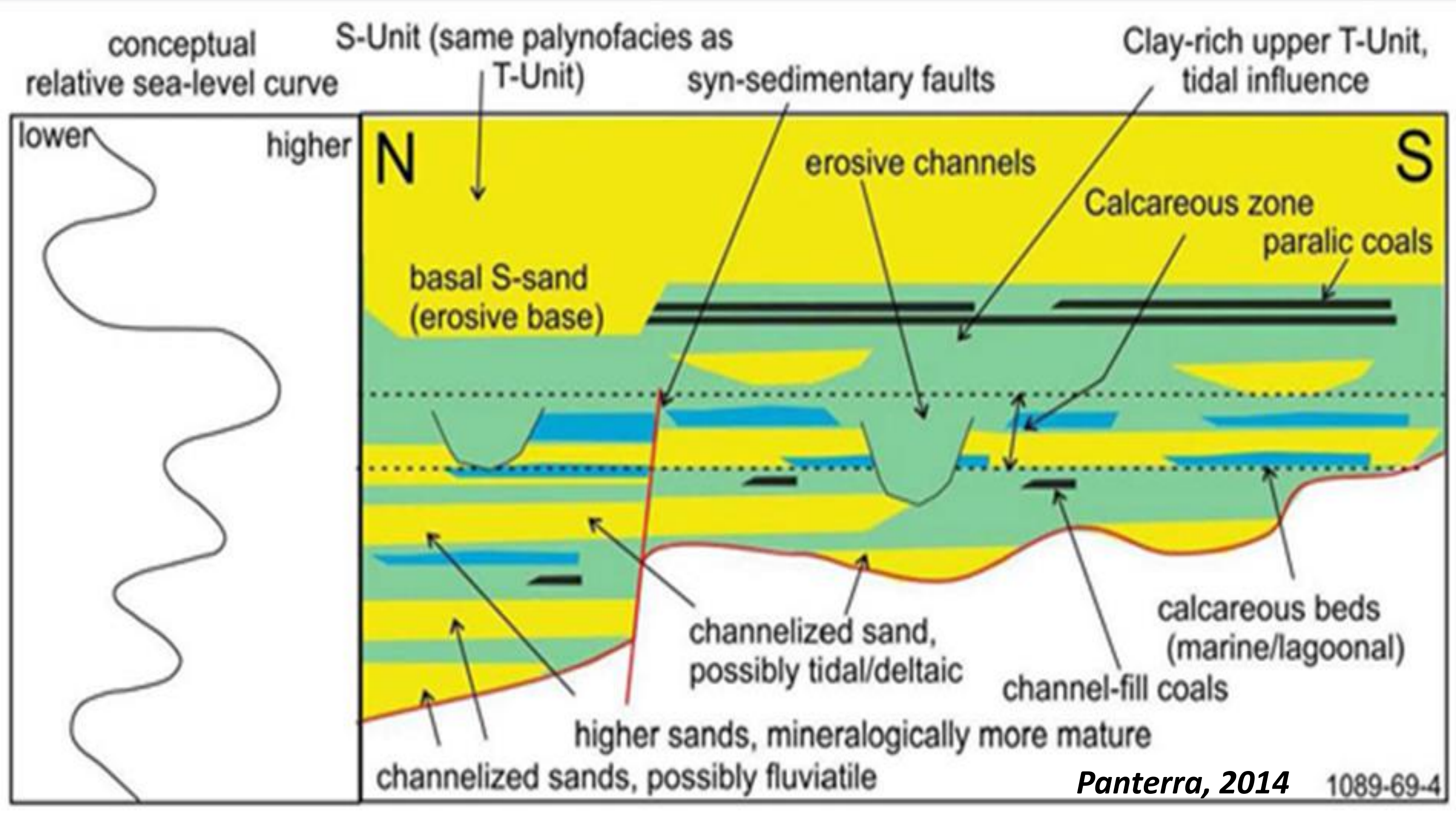
Working Play:

- Tertiary Stratigraphic Traps
- Albian-Cenomanian-Turonian (ACT) Source Rock
- Up-dip migration Southwards to Onshore fields

Nathe, 2012

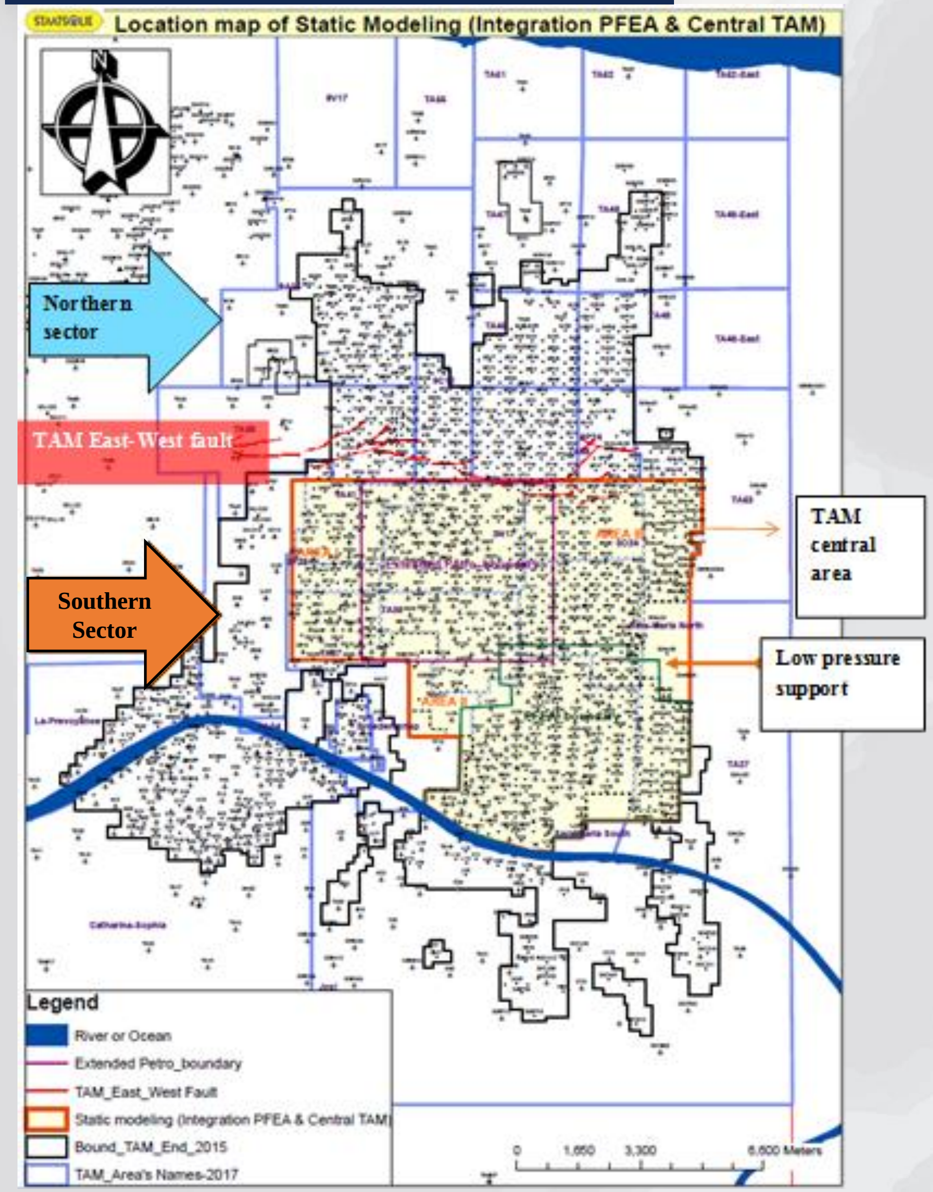
Sedimentological model of TAM field





- Upper to lower delta plain braided to meandering fluvial channels, influenced by shallow marine conditions

Application of EOR in TAM field



- Why EOR?
  - Apparent **production decline**, **increasing water cut** and **depleting pressure** (current primary RF ~15%)

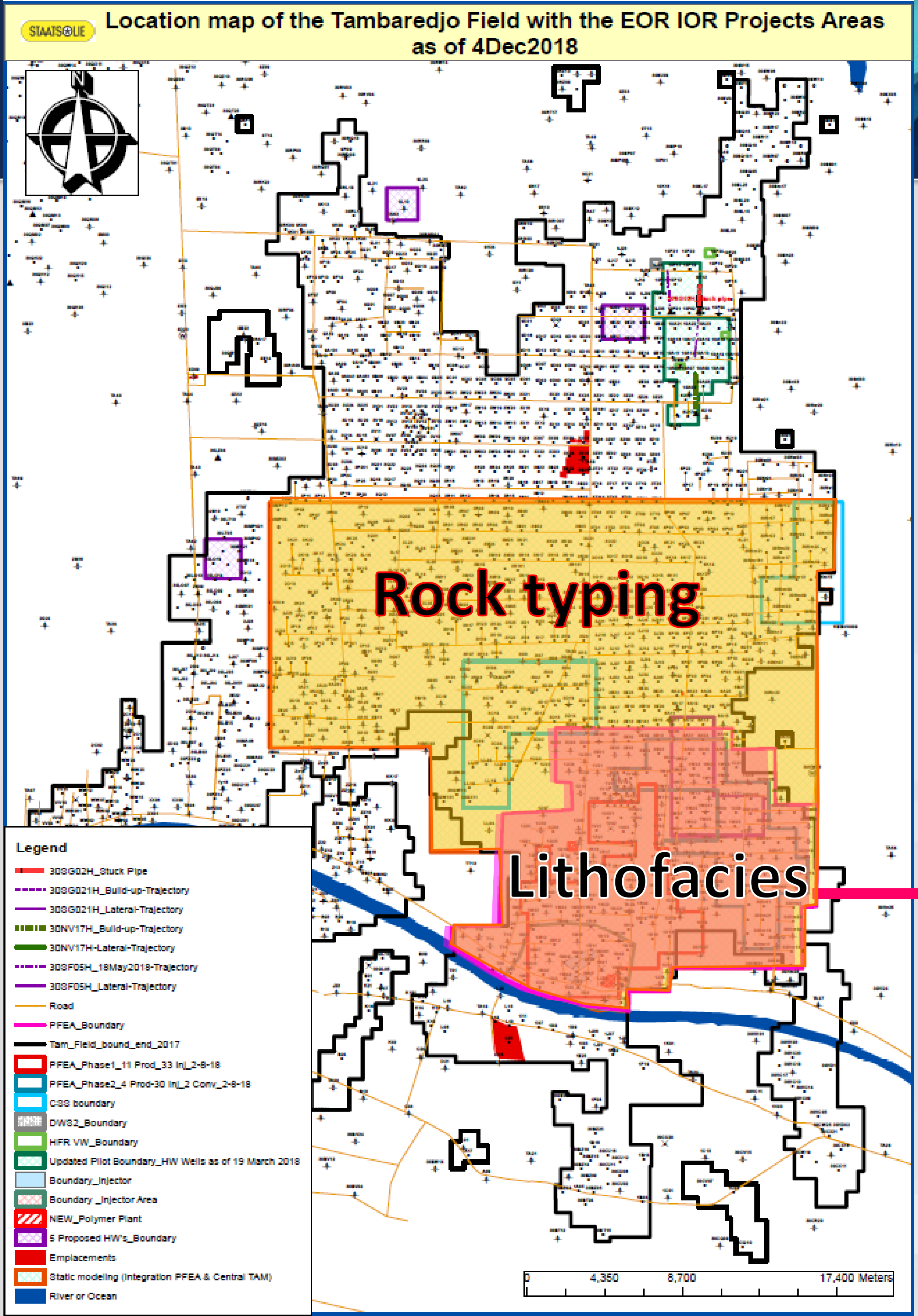
- Polymer flooding pilot since 2008
  - Incr. RF to date: 5-12% OOIP

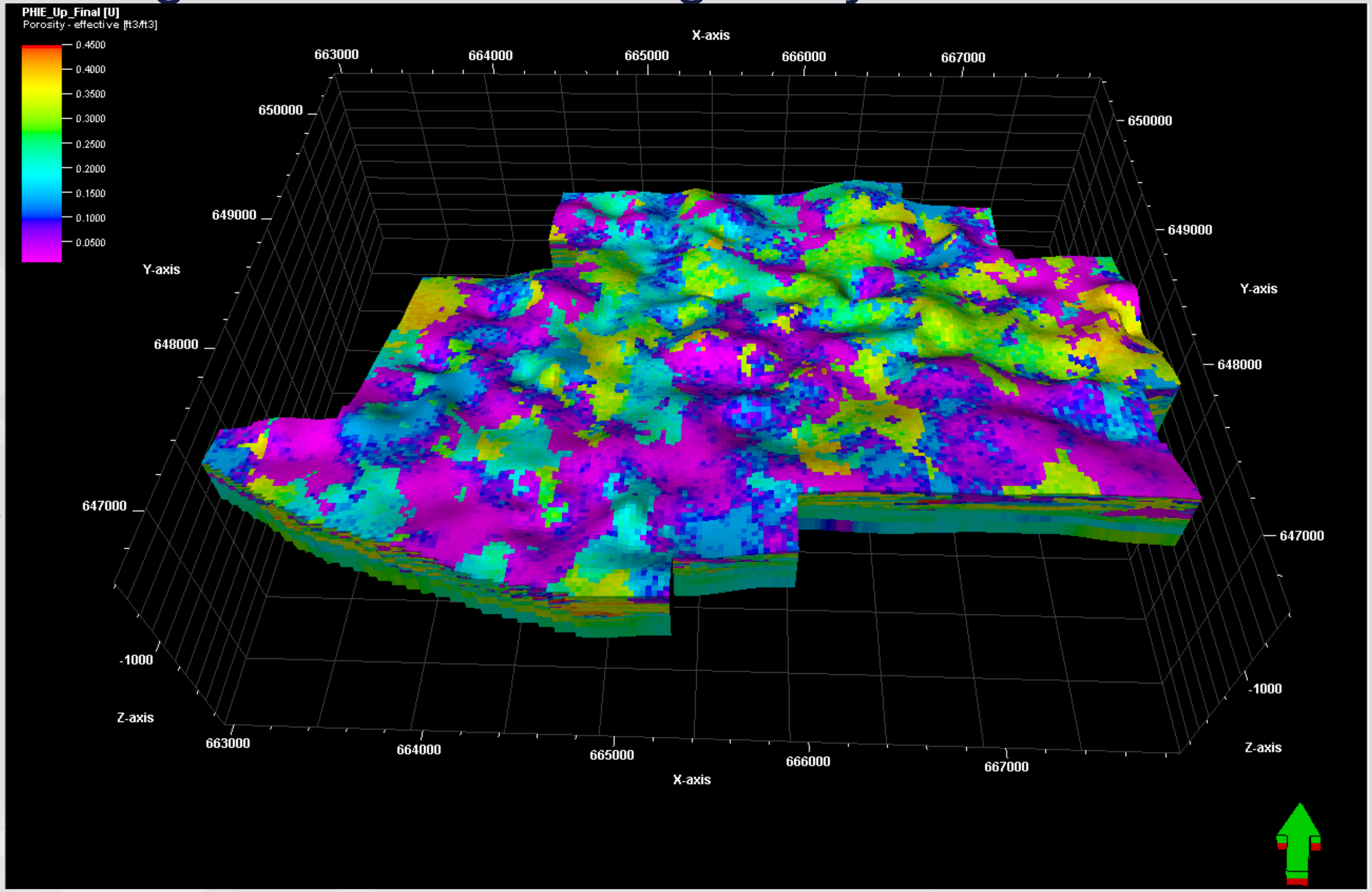
- Robust 3D geocellular model representing **erratic unconsolidated** reservoirs

Application of EOR in TAM field

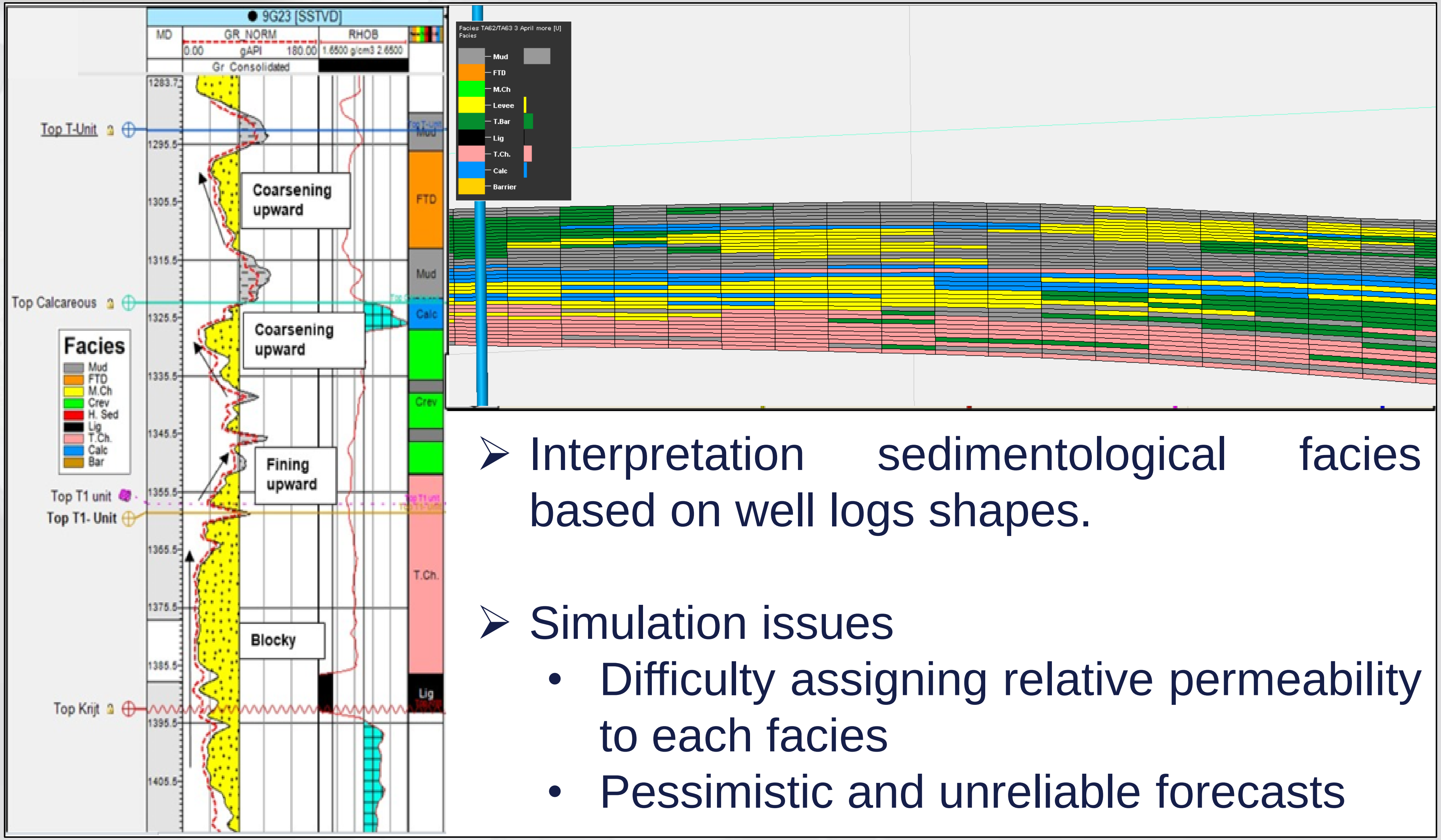
3D modeling challenges

➢ High reservoir heterogeneity





Lithofacies modeling approach



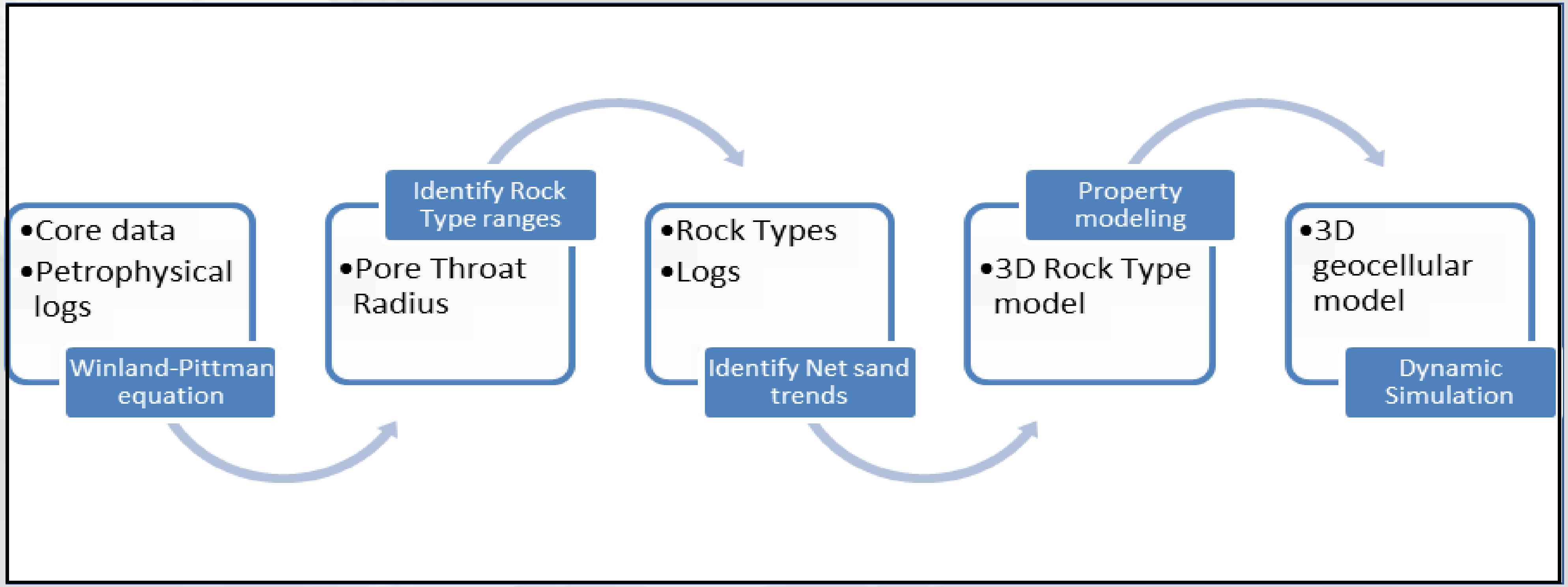
- Interpretation sedimentological facies based on well logs shapes.

- Simulation issues
  - Difficulty assigning relative permeability to each facies
  - Pessimistic and unreliable forecasts

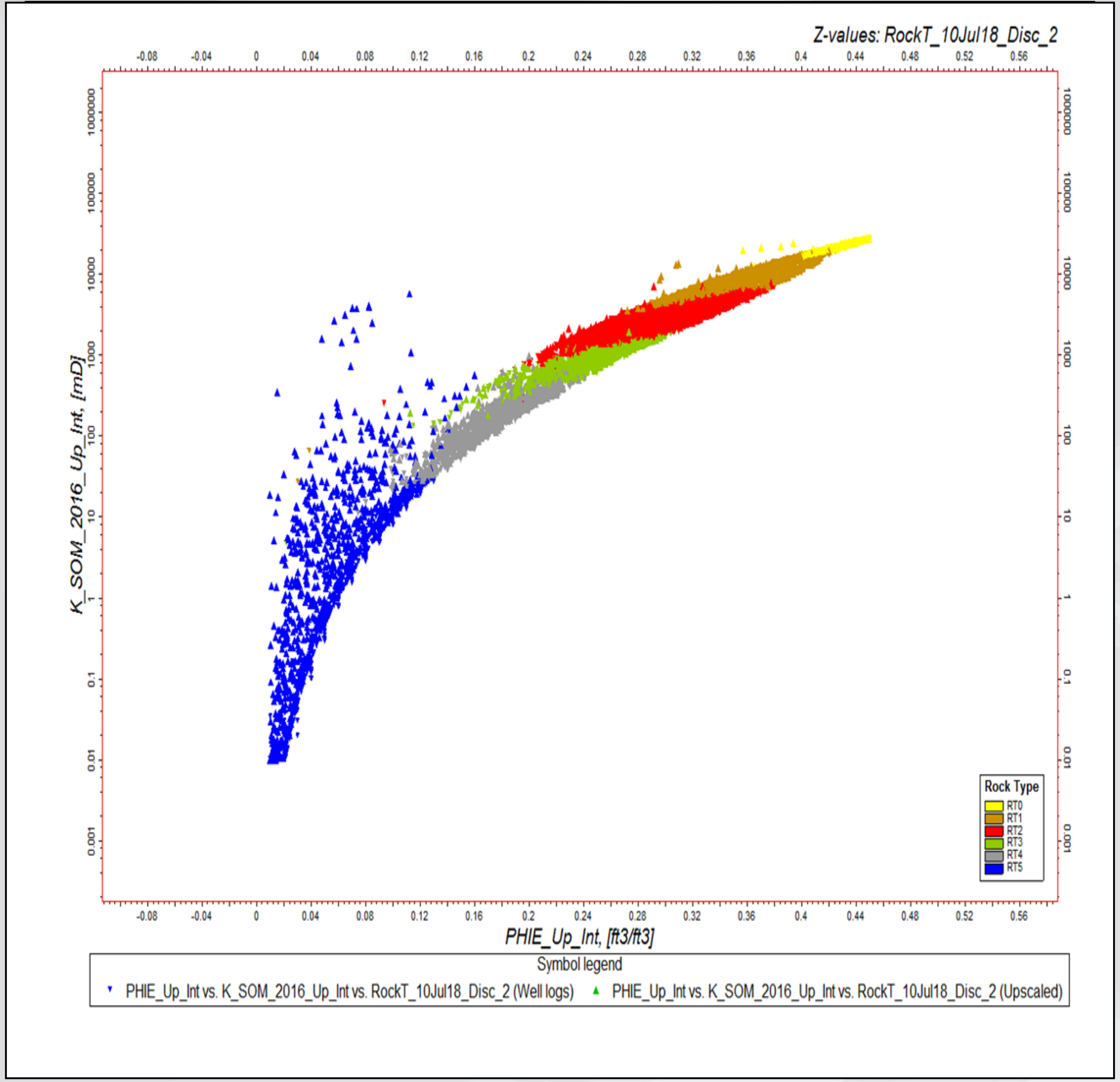
Rock type modeling approach

- Calculation Pore throat Radius (PTR) using Winland-Pittman empirical equation (R55)

- $PTR=10^{(0.948+0.632*\log(PHIE/PERM))-(1.426*\log(PHIE*100))}$



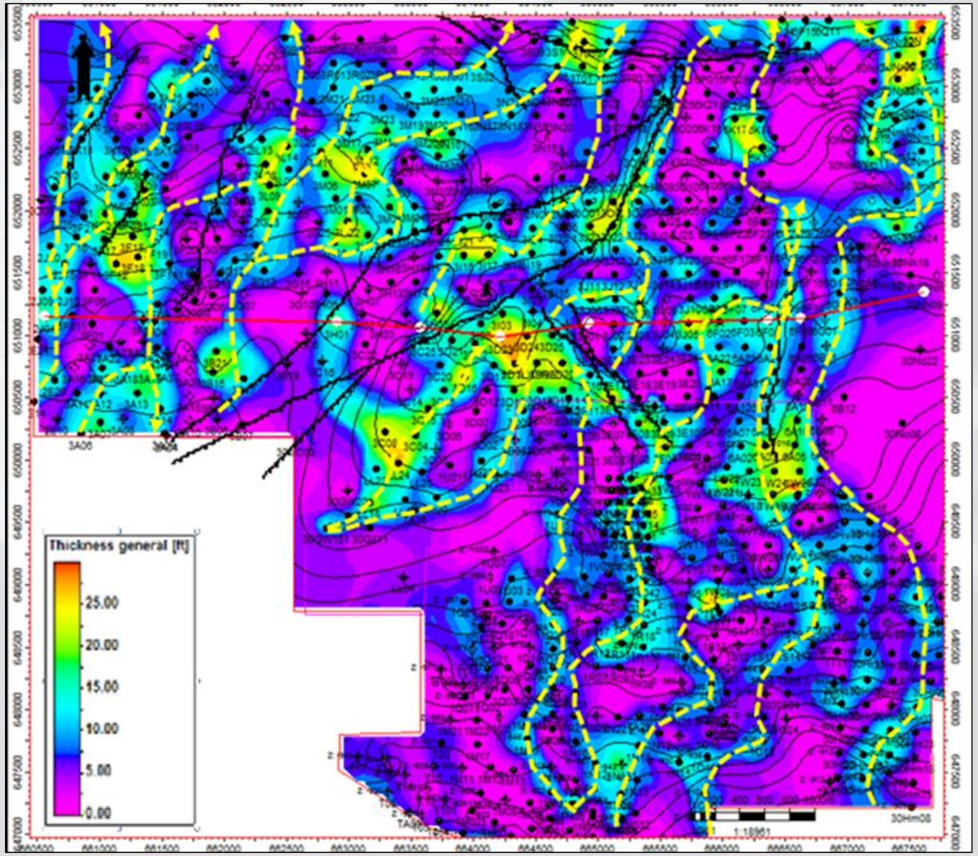
Rock type modeling approach



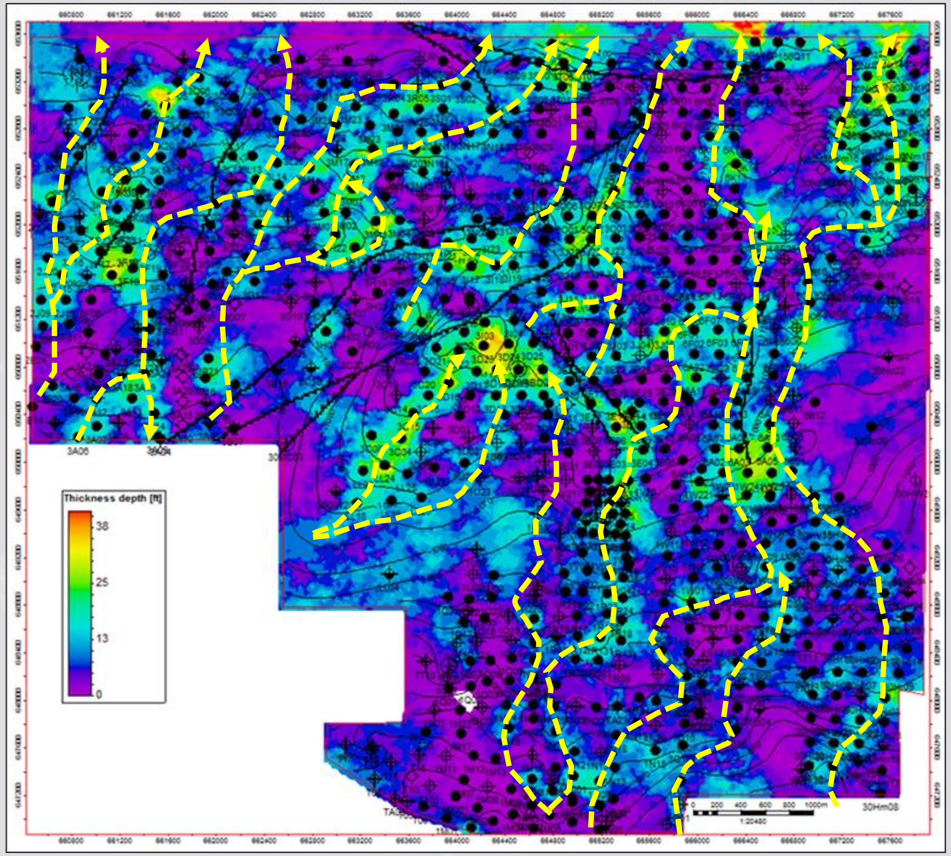
- Definition six (6) rock types based on PTR distribution histogram
- RT0, RT1 and RT2 are the best reservoir rocks
- RT3 to RT5 are transition to non-reservoir rocks

Rock type modeling approach

Netsand trend reservoir

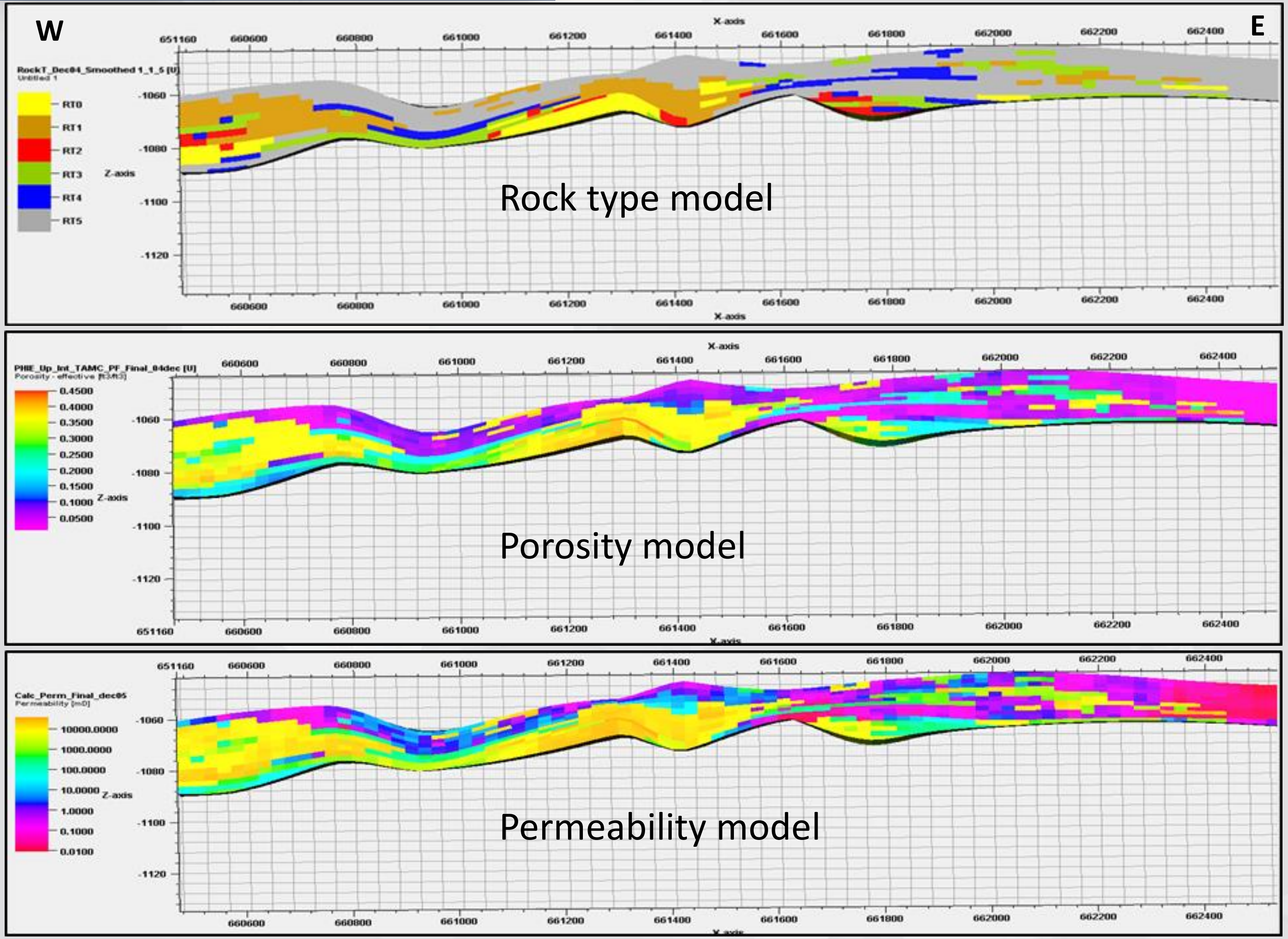


Accumulated thickness of RT0, RT1 and RT2



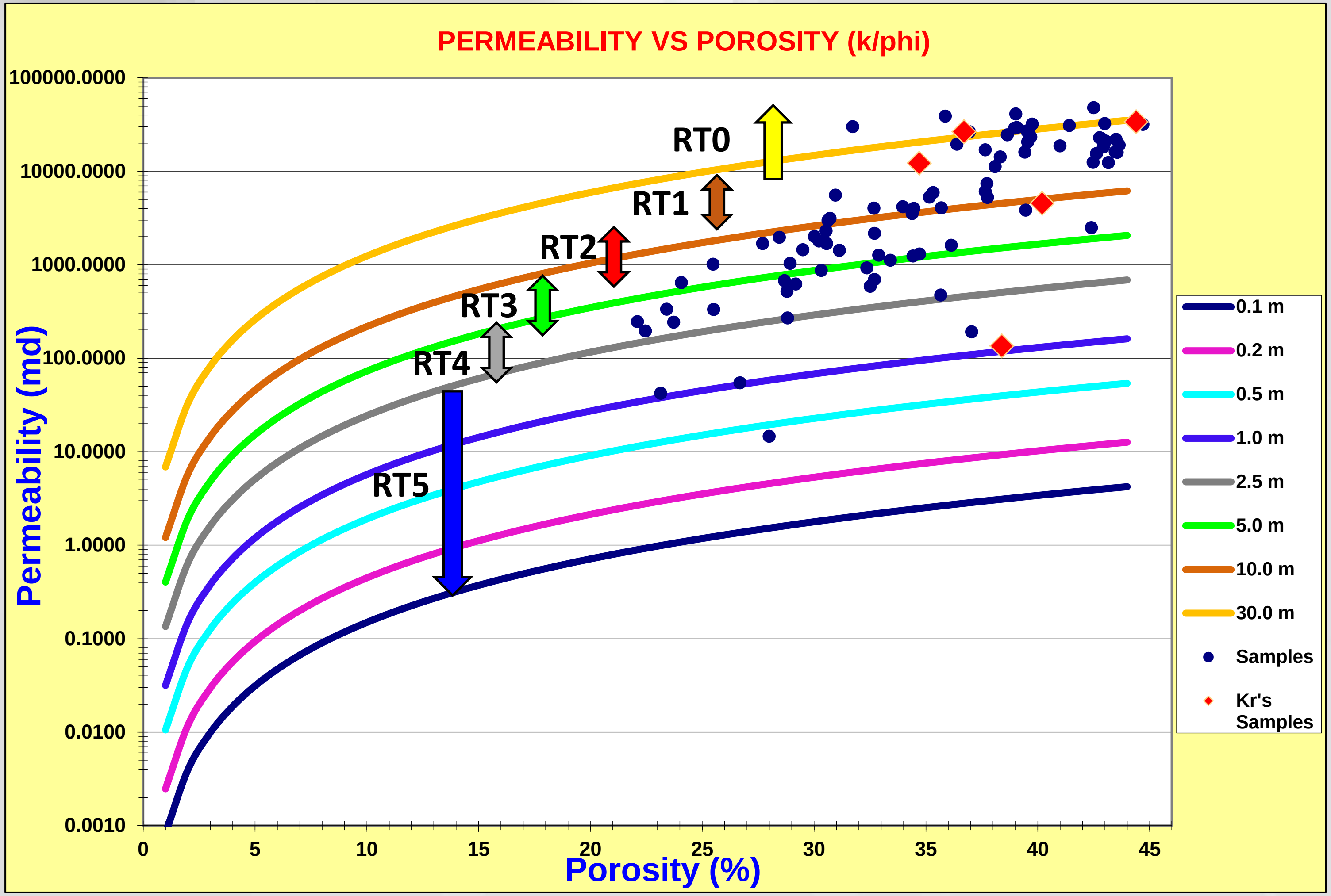
- Rock type modeling guided by **erratic netsand** trend.
- Excellent alignment of thickness of best RT with netsand trend.

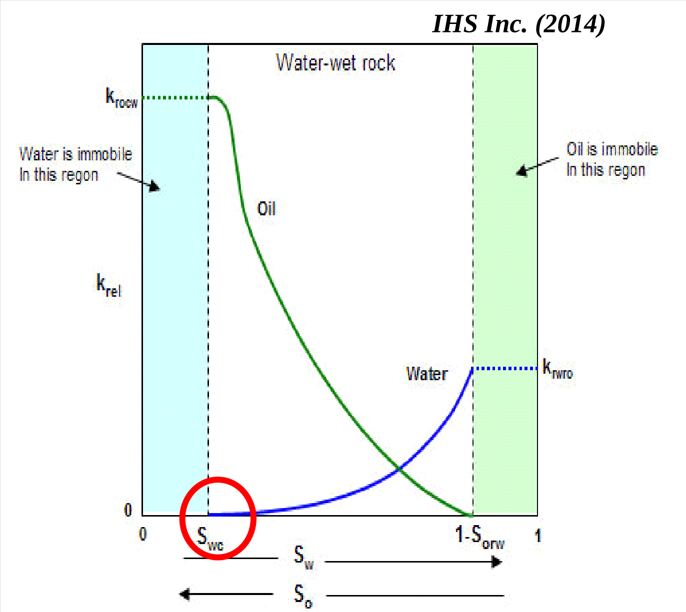
Results and discussions



- ➢ Rock type, porosity and permeability aligned perfect
- ➢ Heterogeneity properly captured
- ➢ How were the simulation issues resolved?

Results and discussions





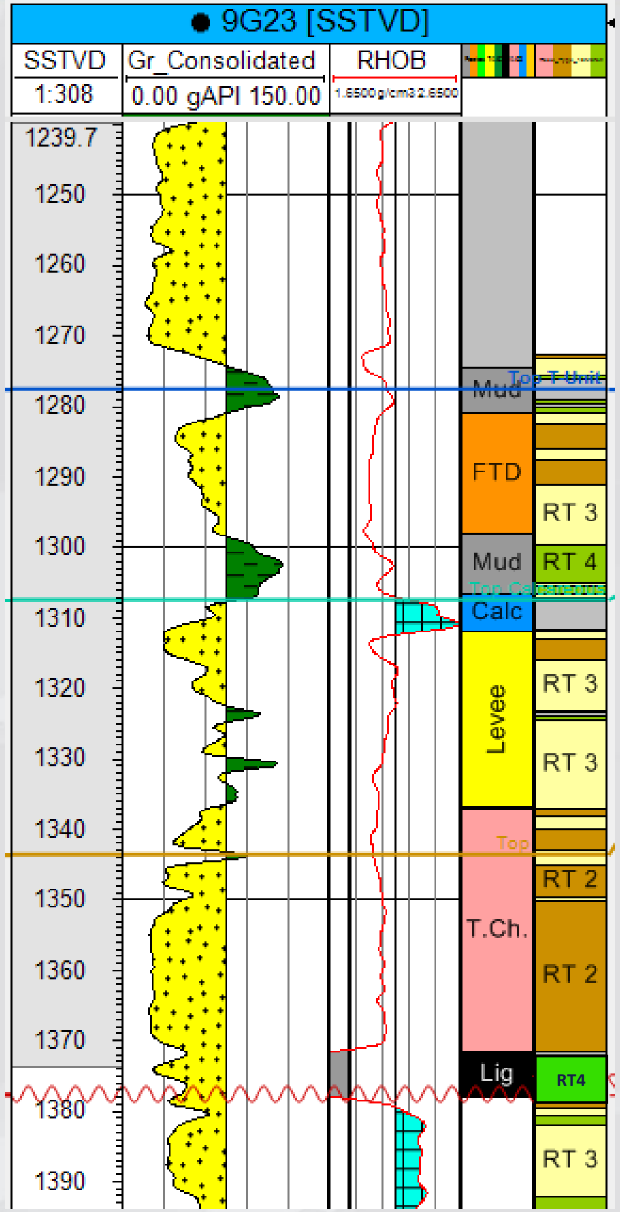
- Simulation solution
  - Characterization flow units
  - Calibration with core data

- Water saturation model: **Initial water saturation** derived from the relative permeability curves

Results and discussions

Lithofacies approach

- Uncertainty in facies determination
- Heterogeneity improperly captured
- Unable to capture multiple flow unit in single facies
- Difficulty assigning flow properties to each facies
- Pessimistic and unreliable forecasts



Rock typing approach

- K and PHIE used in R55 matched core data
- Heterogeneity captured using Netsand trend bias
- Captured multiple flow units in single facies by multiple RT
- Linked relative perm with RT using PTR
- Achievable history match and reliable forecast

Conclusions

- Rock Type approach is a good alternative for assigning relative permeability to each "Rock Facies" in case there is a lack of core data
- Rock Type approach applicable for heterogeneous reservoirs
- STOIIP determination in line with material balance
- Initialization of dynamic model without issues
- Achievable history match and reliable forecast using realistic parameters

THANK YOU

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