Stochastic Geomodel to Understand Reservoir Heterogeneity: A Case Study from Sequoia Field, Offshore Nile Delta, Egypt*

Ahmed Saad[1], Basem K. Abd El-Fattah[2], and Islam A. Mohamed[2]

Search and Discovery Article #42226 (2018)**
Posted June 11, 2018

*Adapted from oral presentation given at GEO 2018 13th Middle East Geosciences Conference and Exhibition March 5-8, 2018, Manama, Bahrain

[1]EGPC, Cairo, Egypt (Ahmed.geoman@yahoo.com)
[2]Rashpetco, Cairo, Egypt

Abstract

Building an accurate static model is critical to understand the reservoir heterogeneity, maintain the production, and optimize new wells locations. The stochastic modeling approach proved significant efficiency as a new and accurate modeling tool. In this case study, we applied the stochastic modeling approach to Sequoia Field. The Sequoia Field is a Pliocene gas field, offshore Nile Delta, Egypt. The field is a delta slope, multi-stacked canyon systems with complex turbidity channel-levee deposits. The canyon-fill consists of sandy channels, levees, crevasse splays, overbank deposits and slumps with multiple fills and incision episodes. The reservoir architecture commonly is the first priority in a stochastic reservoir model and is usually described in terms of different facies to rock types. The Geomodel grid layout was made considering the geological realism. It was constructed from the beginning not to be upscale at the end, on a scale grid design of increment 200x200x2 m mean, with around 4 hundred thousand cells. This increment was selected in such a big field to preserve the heterogeneity of the field with respecting to run time and the maximum number of the cell could be run in a dynamic model.

The new model built has been used to calculate in-place volumes for Sequoia Field. The integrated structural framework of the model was made using the time and depth converted seismic horizons which used to create horizon model in time and depth domain. And the fault sticks were used to create the fault model and eventually the fault surfaces within the reservoir. The facies volume fractions were calculated from wells and considering the gross rock volumes from magnitude maps and inversion volumes. The channel trends were generated out of the voxels created from the inversion products. The reservoir properties like porosity water saturation volumes were modeled stochastically and co-simulated using correlation coefficients biasing to the facies property. Thin bed corrections were made. Hence the in-place volumes were calculated. The Stochastic geomodel optimizing on the grid resolution, incorporating interpretations from a new interpretation of seismic and inversion data and all well log analysis to match history, provide better water predictions and planning of additional wells if needed. This model will be the basis for dynamic modeling and will help in any further field development planning.

Acknowledgments

The authors thank the Egyptian General Petroleum Corporation (EGPC) and Rashid Petroleum Company (RASHPETCO) for their permission to publish this study and for providing the data.

References Cited

Cross, N.E., A. Cunningham, R.J. Cook, A. Taha, E. Esmaie, and N. El Swidan, 2009, Three-dimensional seismic geomorphology of a deep-water slope-channel system: The Sequoia field, offshore west Nile Delta, Egypt: AAPG Bulletin, 93/8, p. 1063-1086.

Mohamed, I.A., O. Shenkar, and H. Mahmoud, 2017, Understanding reservoir heterogeneity through water saturation prediction via neural network - A case study from offshore Nile Delta: The Leading Edge, 36/4, p. 298-303.

Samuel, A., B. Kneller, S. Raslan, A. Sharp, and C. Parsons, 2003, Prolific deep-marine slope channels of the Nile Delta, Egypt: AAPG Bulletin, 87/4, p. 541-560.

GEO 2018
13th Middle East Geosciences Conference and Exhibition
CONFERENCE: 5 – 8 March 2018
EXHIBITION: 6 – 8 March 2018
BAHRAIN INTERNATIONAL EXHIBITION & CONVENTION CENTRE

Stochastic Geomodel to Understand Reservoir Heterogeneity: A Case Study from Sequoia Field, Offshore Nile Delta, Egypt

Ahmed Saad[1]* , Basem K. Abd El-Fattah[2] , and Islam A. Mohamed[2]

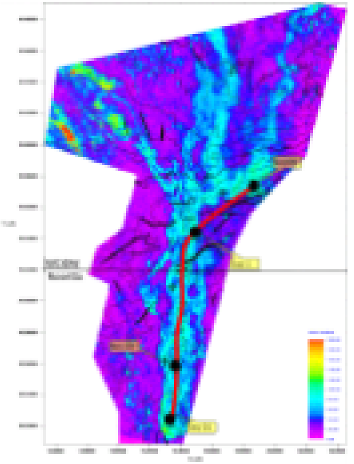
1. EGPC, Cairo, Egypt.

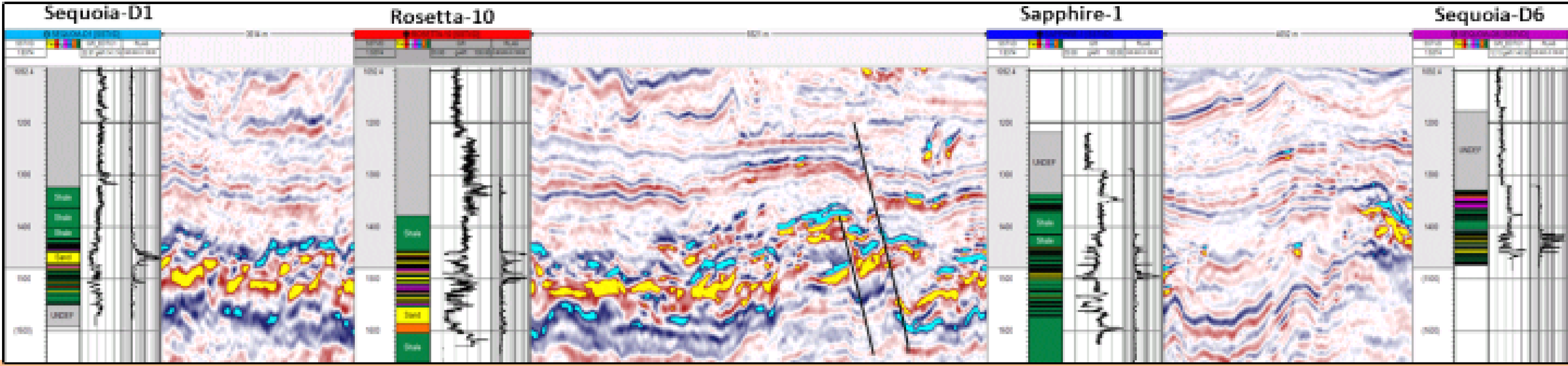
Contents :

- Objectives
- Introduction
- Workflow
- Conclusion

Objectives

- Understanding and modeling:
  - heterogeneity of slope marine channel complexes (Sequoia channel system).
  - Heterogeneity in reservoir properties includes facies, PHIE, SW, and KTIM. using stochastic techniques (Variogram/geostatistical algorithms/3D trends)
- Gas volume estimation.

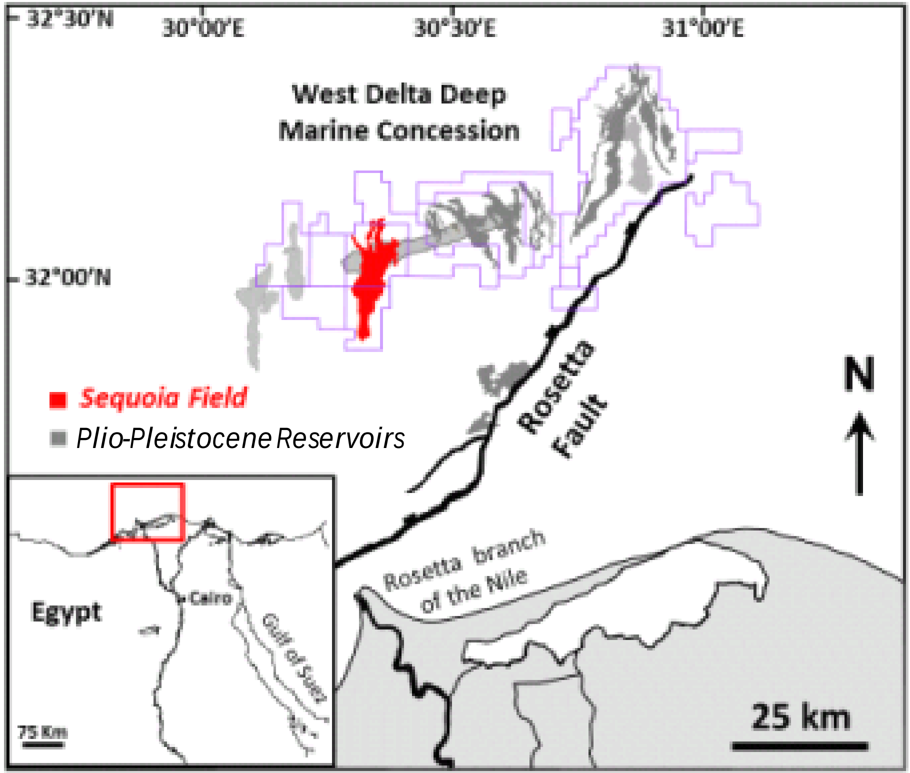




Introduction

Location

Sequoia channel complex, lies in the West Delta Deep Marine (WDDM) concession, 50 –100 km offshore in the deep water of the present-day Nile Delta

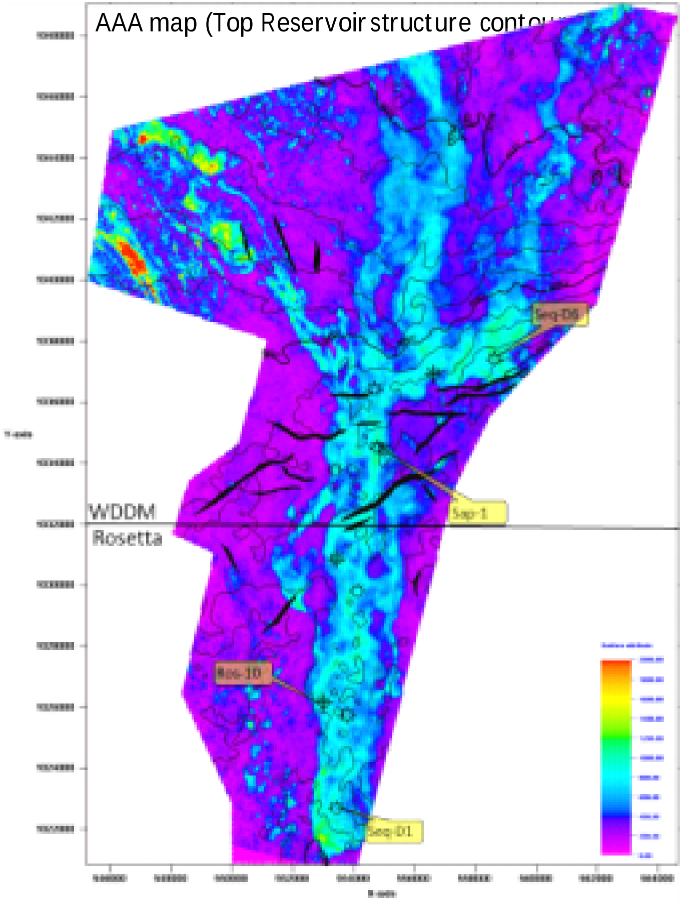


(From Mohamed et al., 2017)

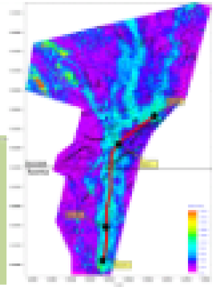
Introduction

Reservoir Geology

- Plio-Pleistocene submarine delta slope canyon system.
- Sandstones and mud-stones successions organized into a composite upward-fining profile.
- Trapped as combination trap (stratigraphic and structural)
- Discovered based on seismic amplitude anomaly (bright spot and flat spot associated with GWCs)
- Cumulative gas: 665 Bscf

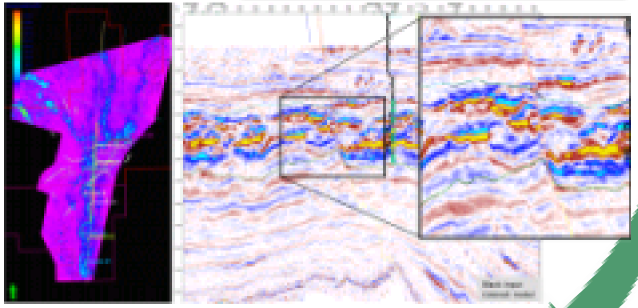


Reservoir Modeling Workflow



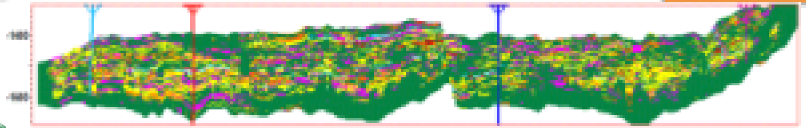
- 4 wells
- 3D Seismic
- Inversion
- Horizons

Data Collection & Input

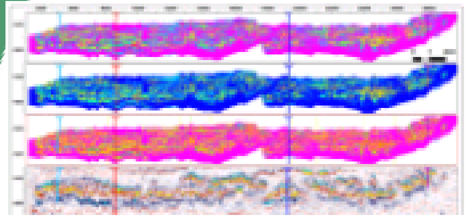


Structural Modeling & Grid building

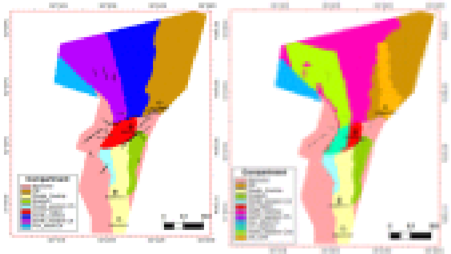
Scale Up well log



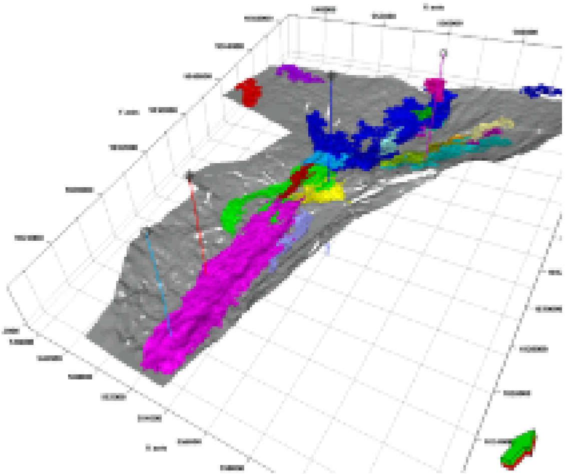
Facies Modeling



Petrophysical Modeling



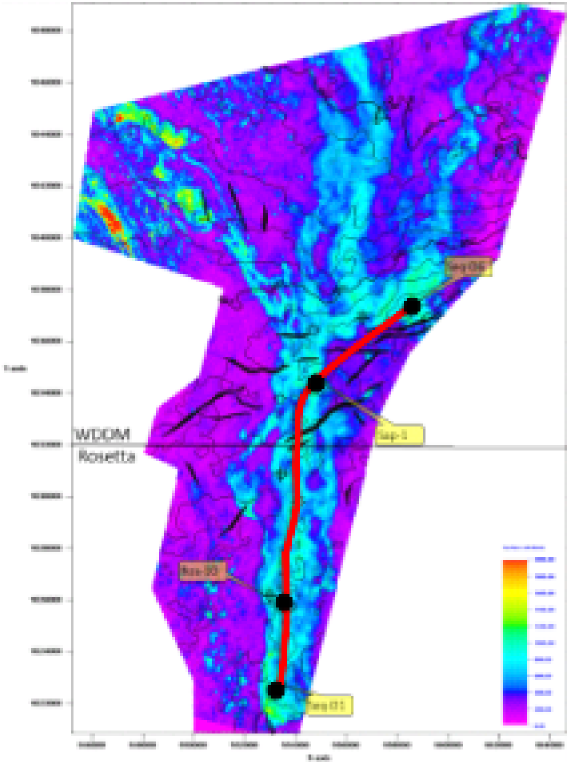
Volumetrics



Workflow

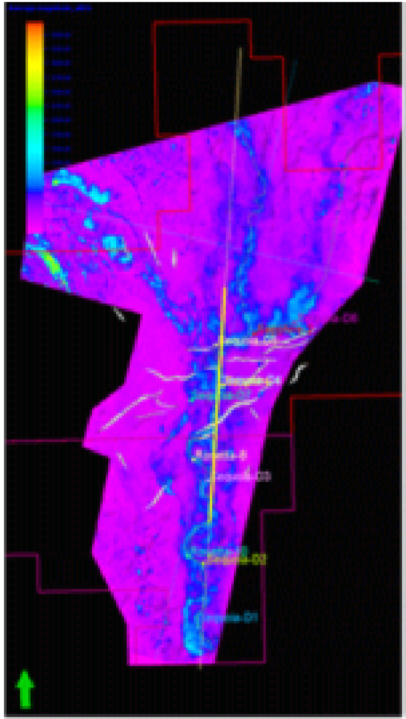
Data Collection & Input

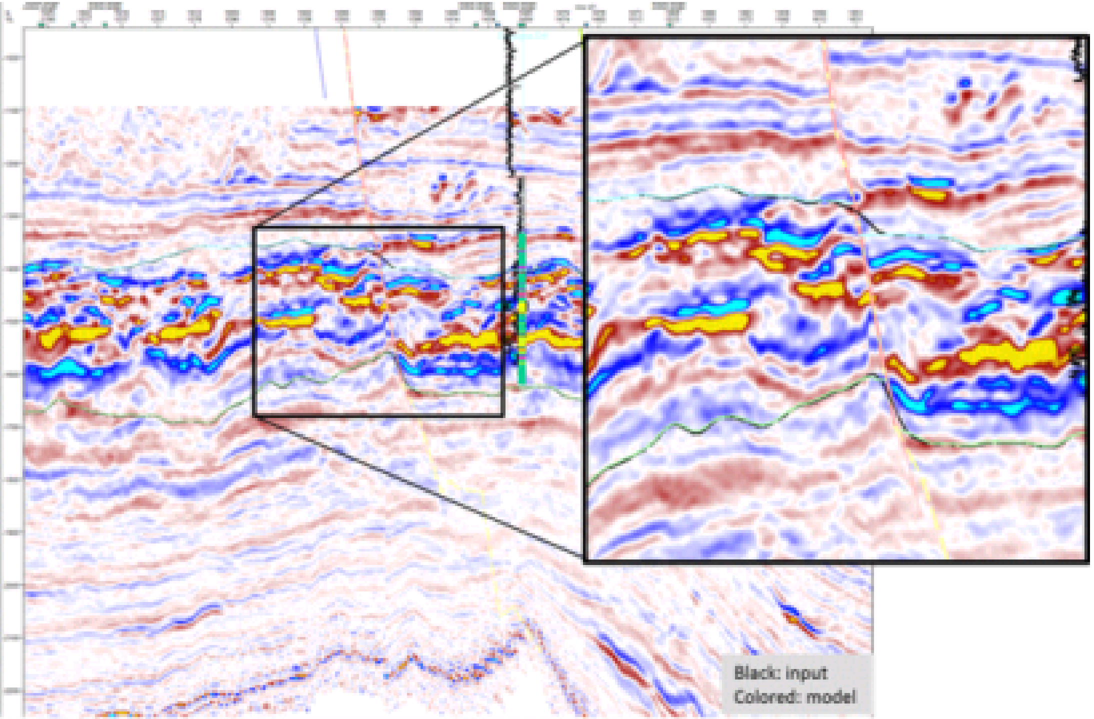
- Only 4 wells used (2 Exploratory and 2 Development).
- A full set of conventional open hole logs.
- Processed logs- PHIE, SW, and KTIM
- Core and FMI data.
- 3D Seismic Volume.
- Inversion volume: P-impedance (pre-stack inversion).
- Structural maps (Channel Top ,Base Gas, and Channel Base).
- Fault sticks and fault polygons.
- Amplitude maps.



Workflow

Structural Modeling



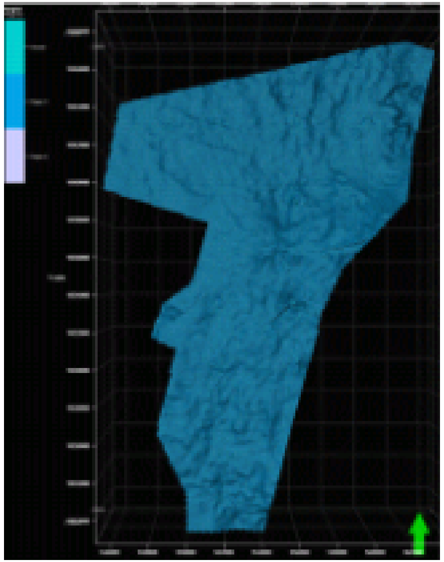


Workflow

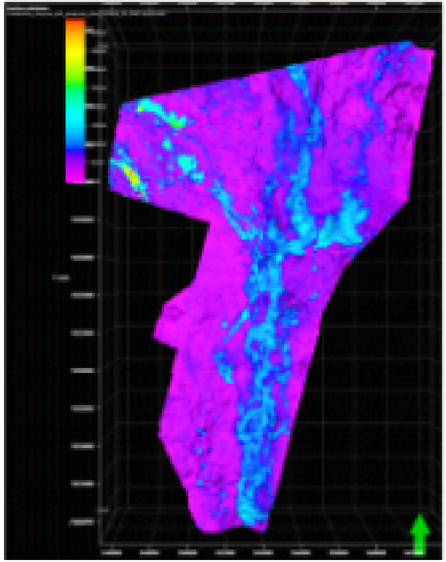
Grid building/QC

The grid has been built with cell size 100m*100m using proportional layering (1.5m Average cell thickness)

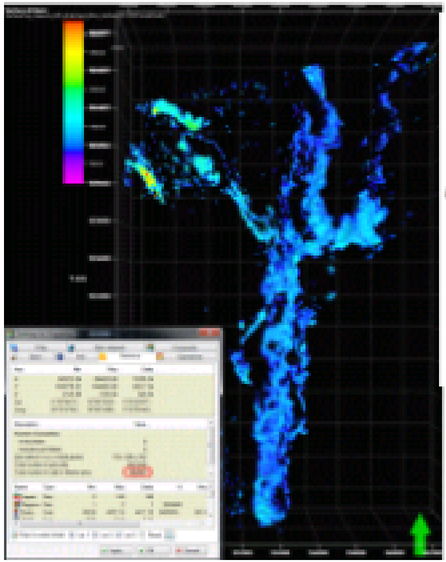
Grid Design



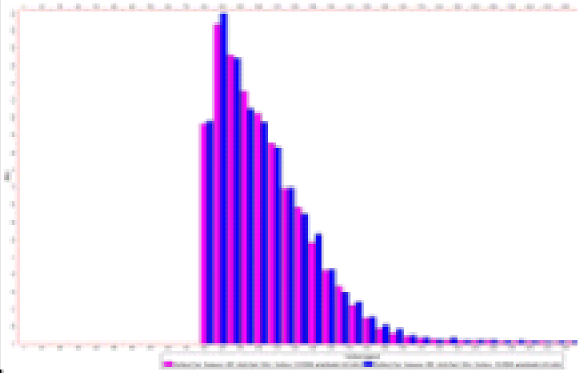
Resmpled attribute map



Filtered resampled attribute map



Histogram Comparison



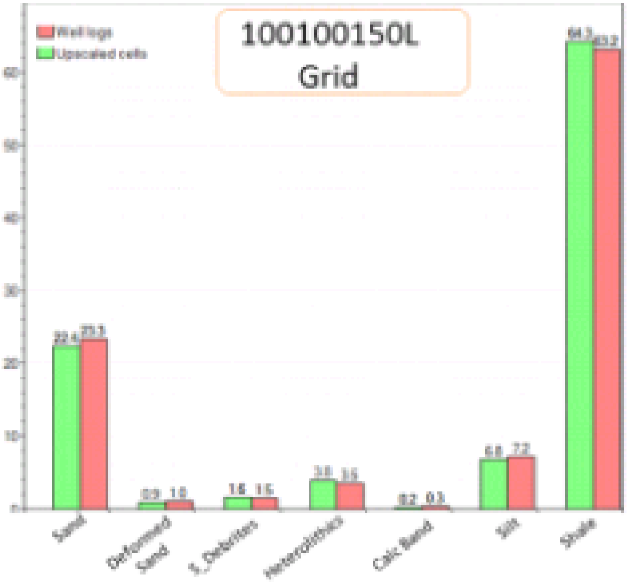
Total No. of cells (filtered)

100*100*150L

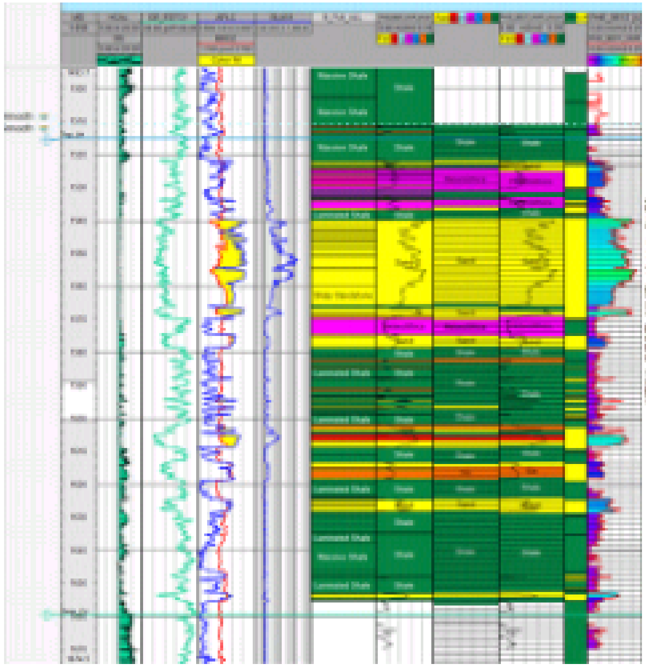
882597

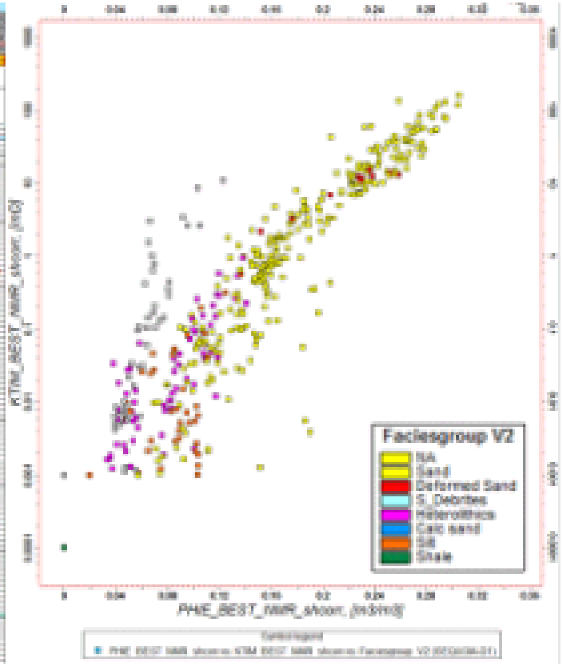
Workflow

Grid building/ QC (Scale Up well logs)



Sequoia-D1 well



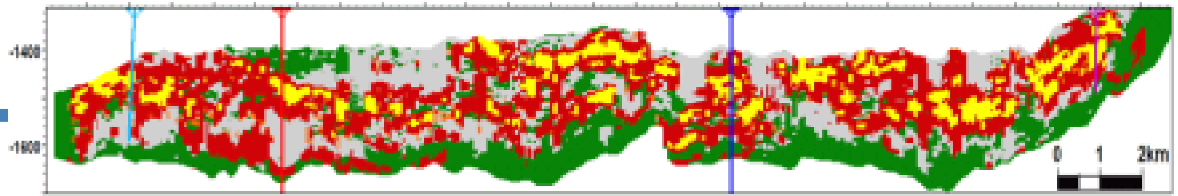


Workflow

Facies Modeling

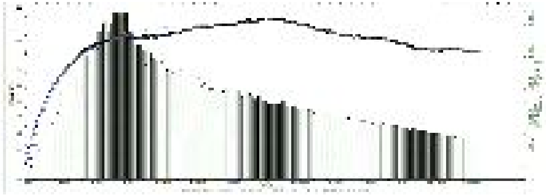
Inputs
- Upscaled Facies logs
- 3D Trend

NN_derived Seismic facies classes



Output: seismic classes

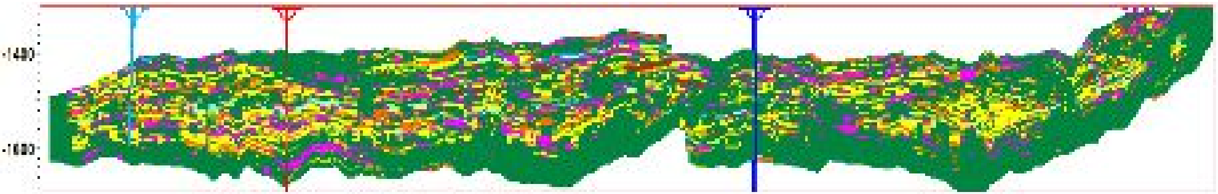
Using NN to make seismic facies classification



Variogram

Facies modeling: SIS
- Seismic classes
- Variogram analysis
- Facies % for each seismic class
- 3D trend

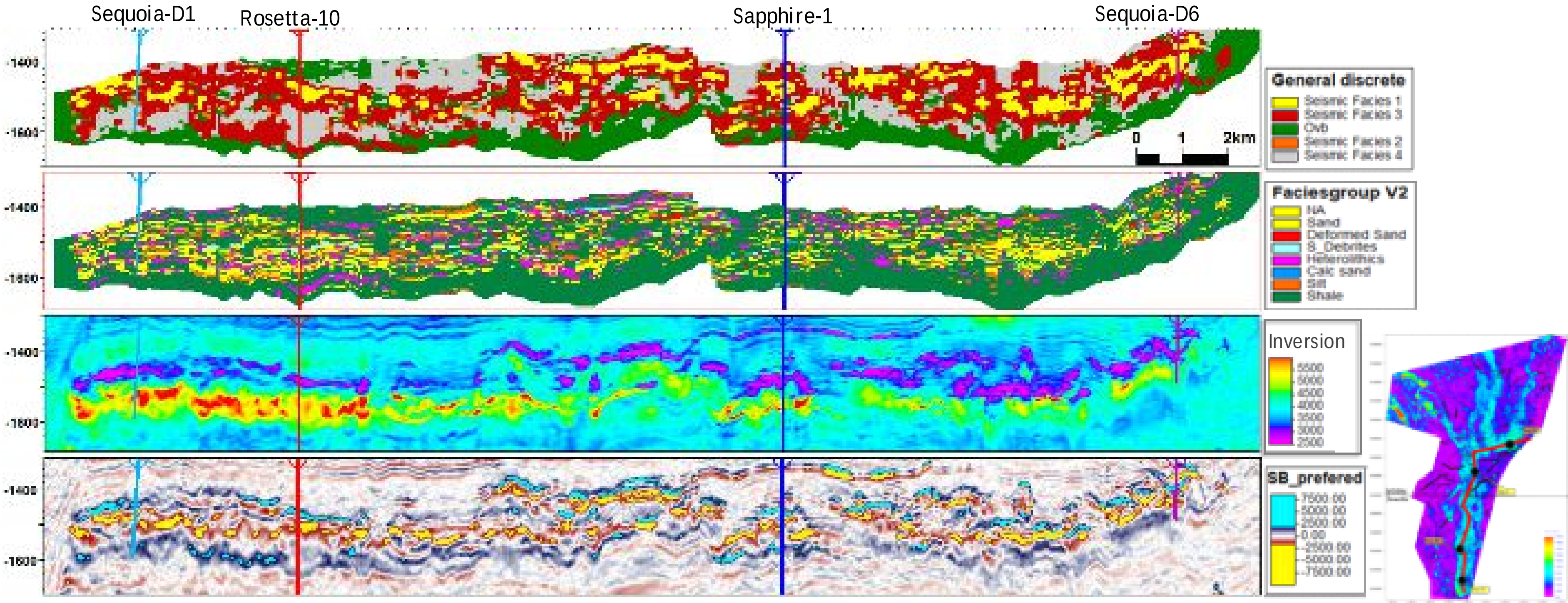
3D Facies property



Output Facies

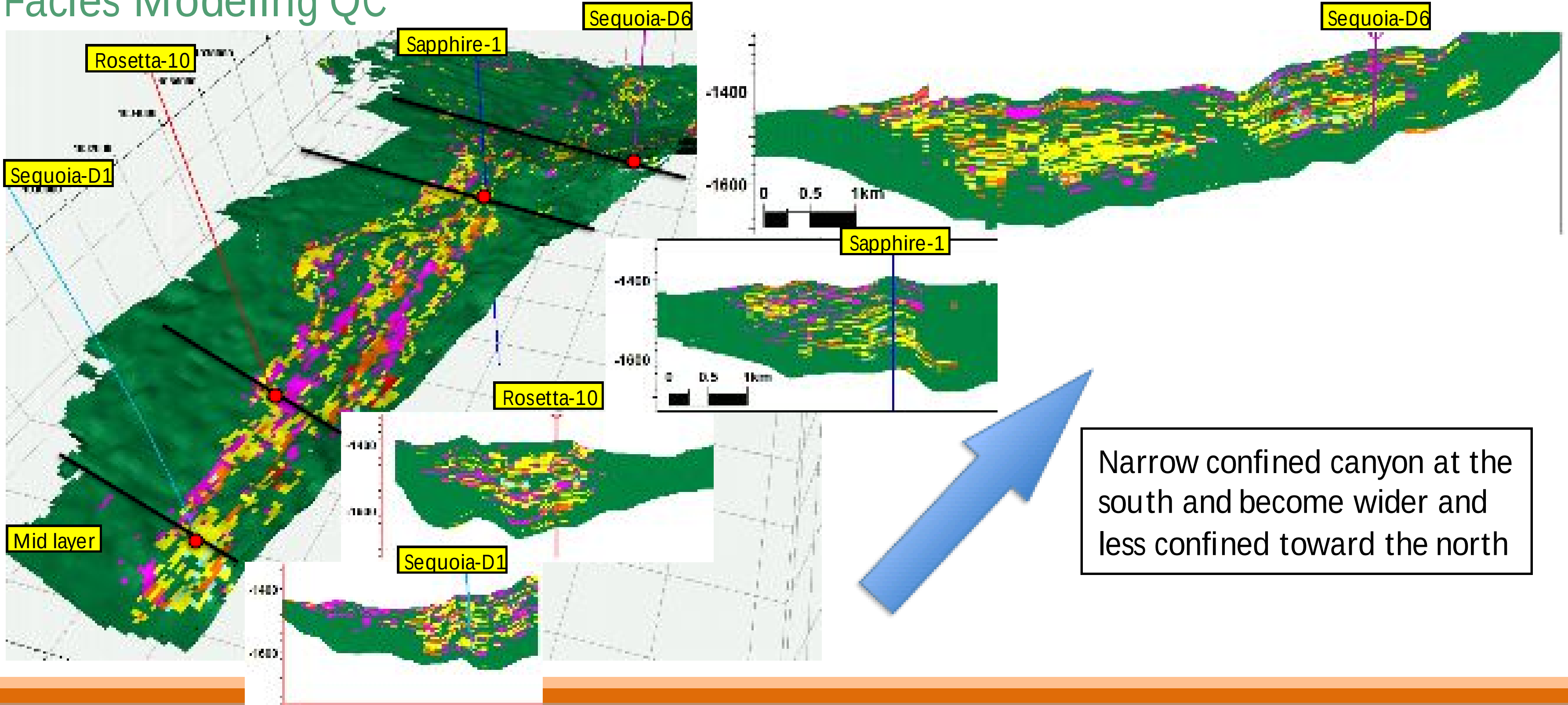
Workflow

Facies Modeling



Workflow

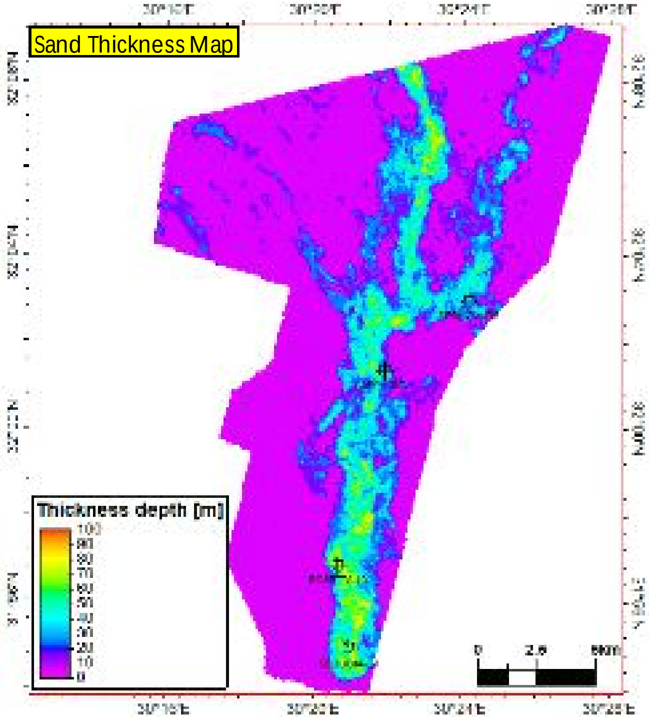
Facies Modeling QC

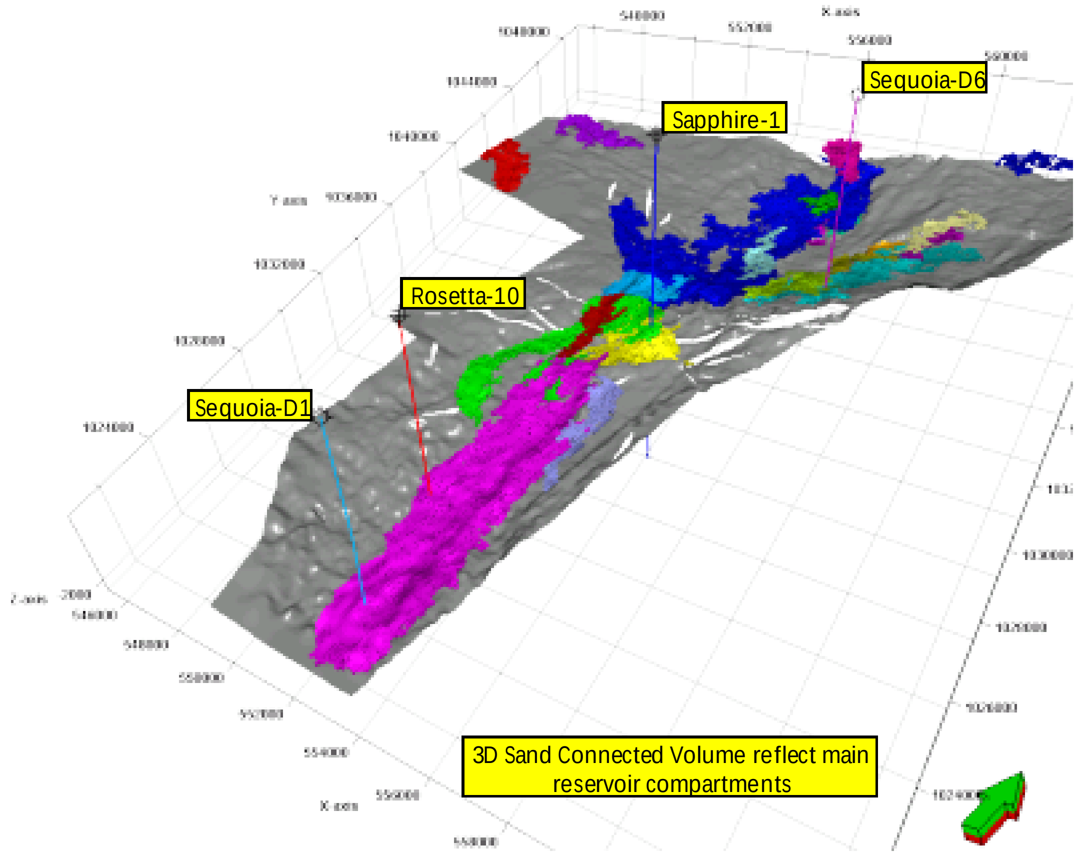


Narrow confined canyon at the south and become wider and less confined toward the north

Workflow

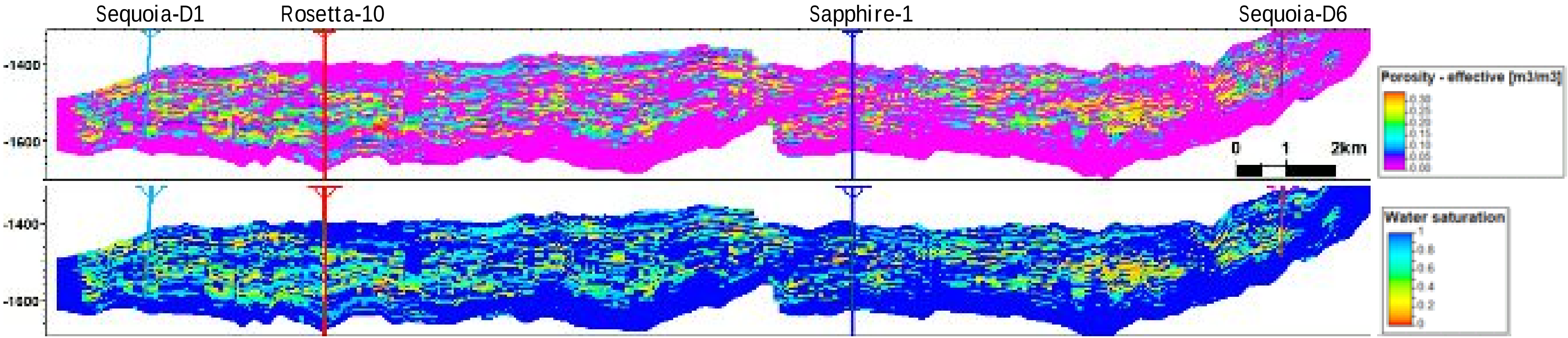
Facies Modeling QC

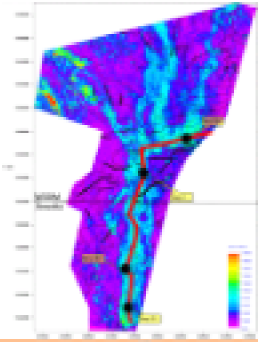




Workflow

Petrophysical Modeling (Effective Porosity & Water Saturation)

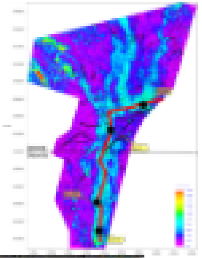


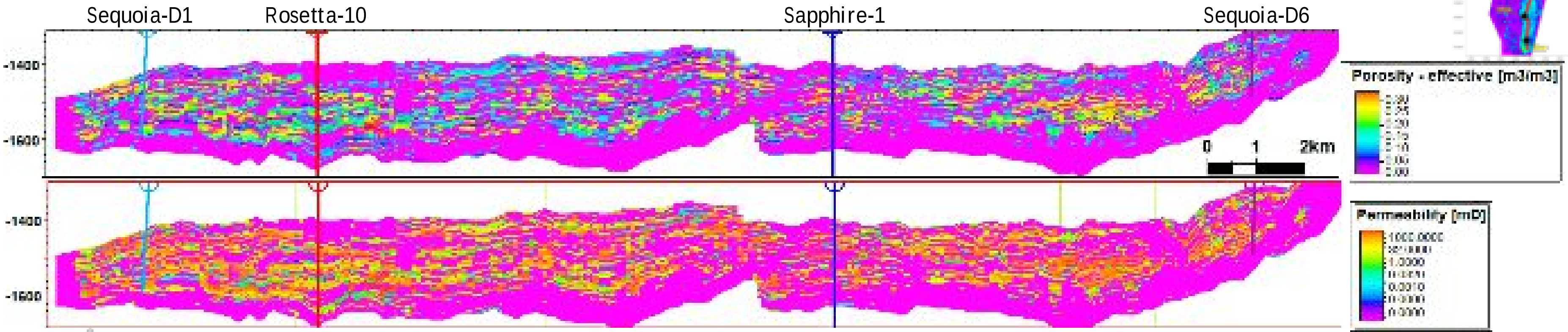


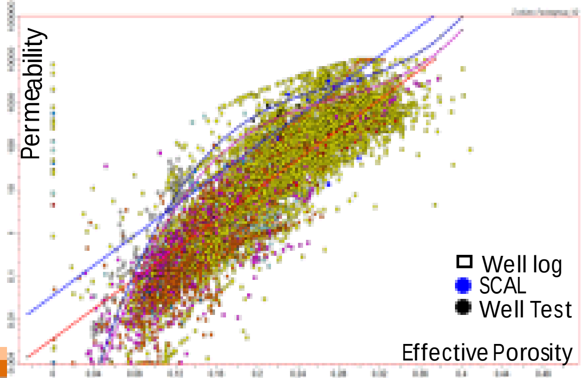
- SGS algorithm.
- Depends on upscaled well logs including PHIE and SWE.

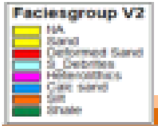
Workflow

Petrophysical Modeling (Effective Porosity & Permeability)







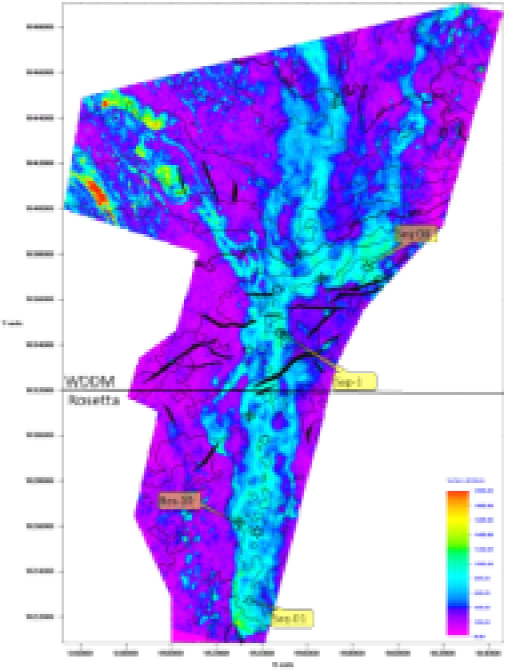


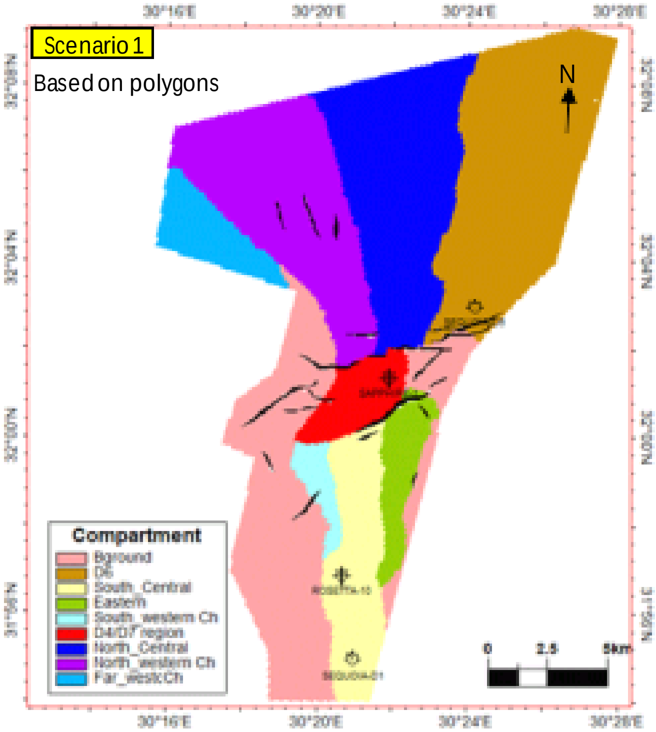
$$\text{Log}(K) = -7.16723 + 98.7652 * \text{pow}(\phi,1) - 334.763 * \text{pow}(\phi,2) + 404.821 * \text{pow}(\phi,3)$$

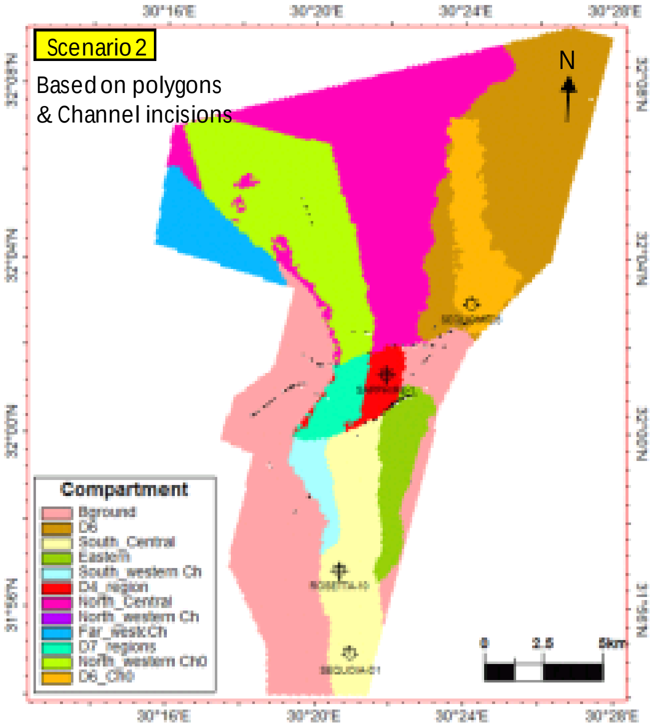
Poro-perm relationship: third order polynomial equation

Workflow

Volumetrics: Regions

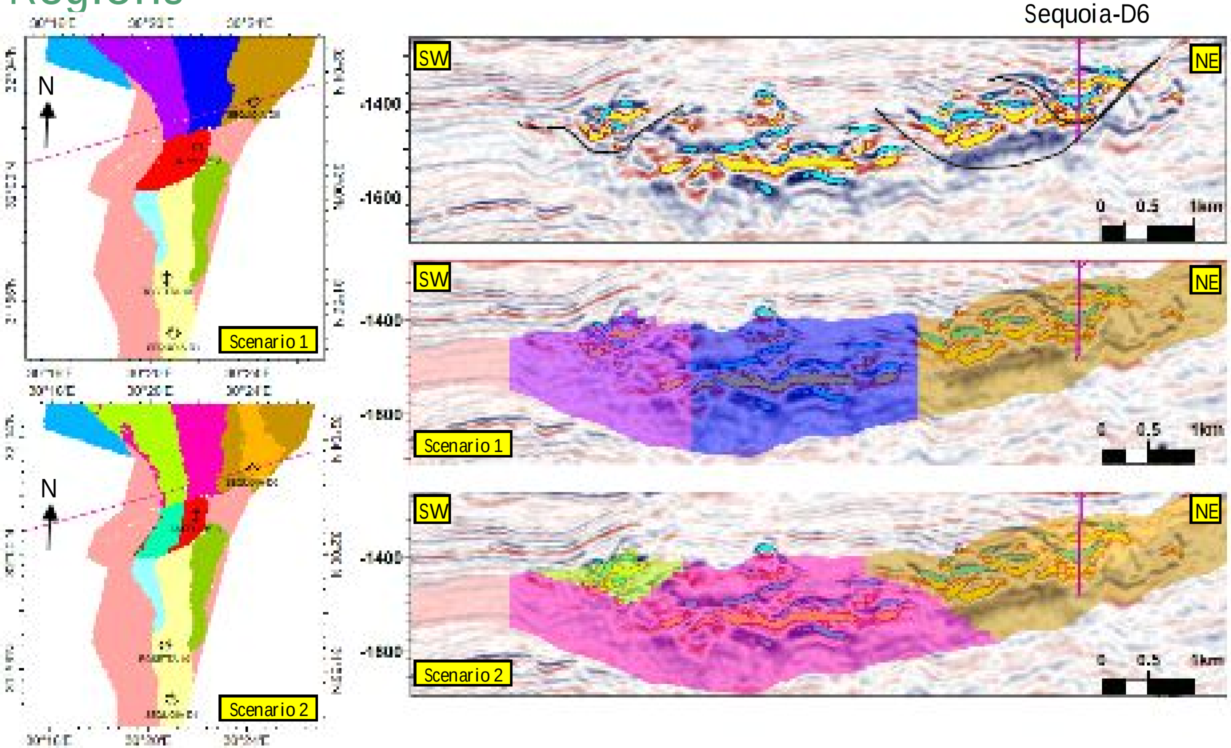




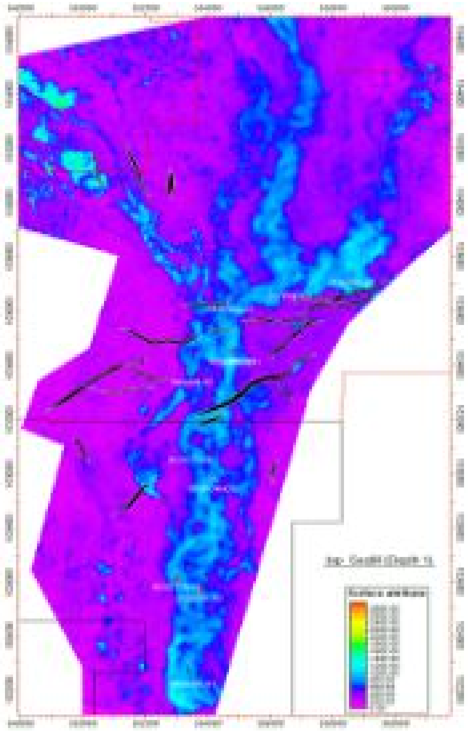


Workflow

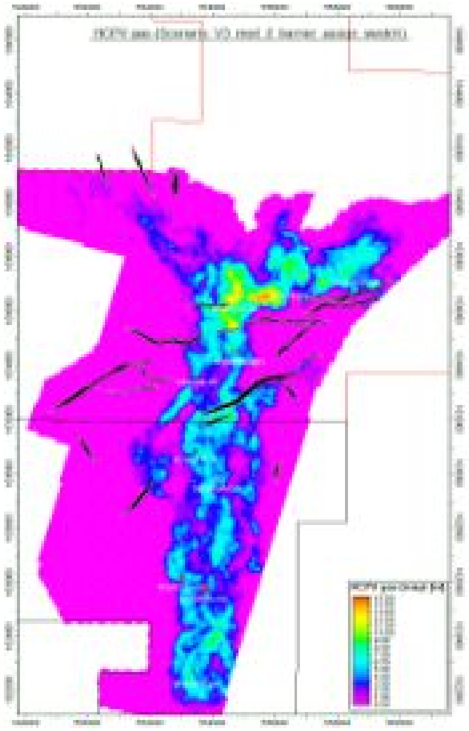
Volumetrics: Regions



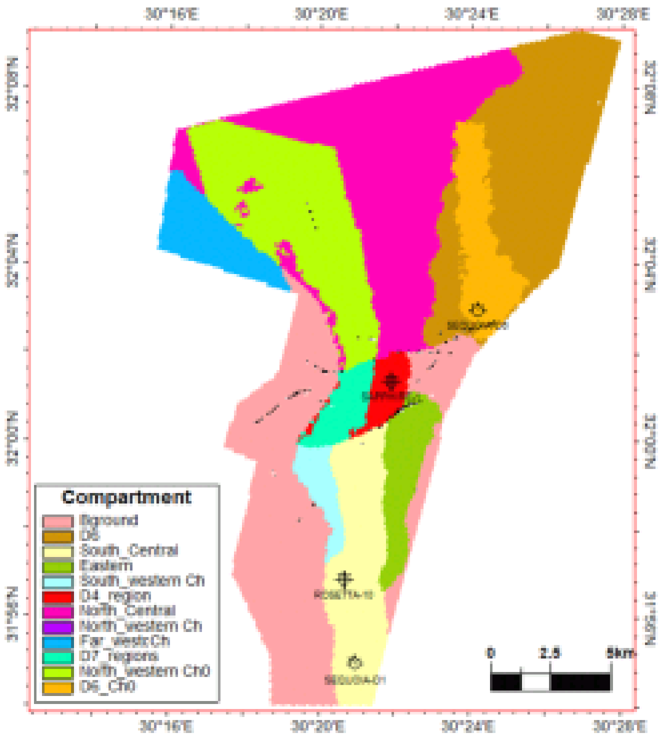
Volumetrics: Volume



RMS Amplitude Map



GIIP by Region = 1708.01



Recommended in Simulation

Conclusion

- Applying stochastic geomodeling workflow helps in representing the reservoir heterogeneity in terms of facies and Petrophysical modeling via using :
  - Variogram analysis.
  - Geostatistical algorithm.
  - 3D seismic trend.

- Volume estimation is one of the main result of work. It is estimated to be 1.7 TCF and about 40% has been produced.

- Although it is possible but still too difficult to allocate a well in the reservoir because :
  - Its heterogeneity.
  - Low relief structure.
  - Its complicated dynamic history.

THANKS