



Terra3E

Energy Environment Expertise

VolTerra

A plug-in of Terra 3E for Assessing Hydrocarbons in Place and their Associated Uncertainties

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Outline

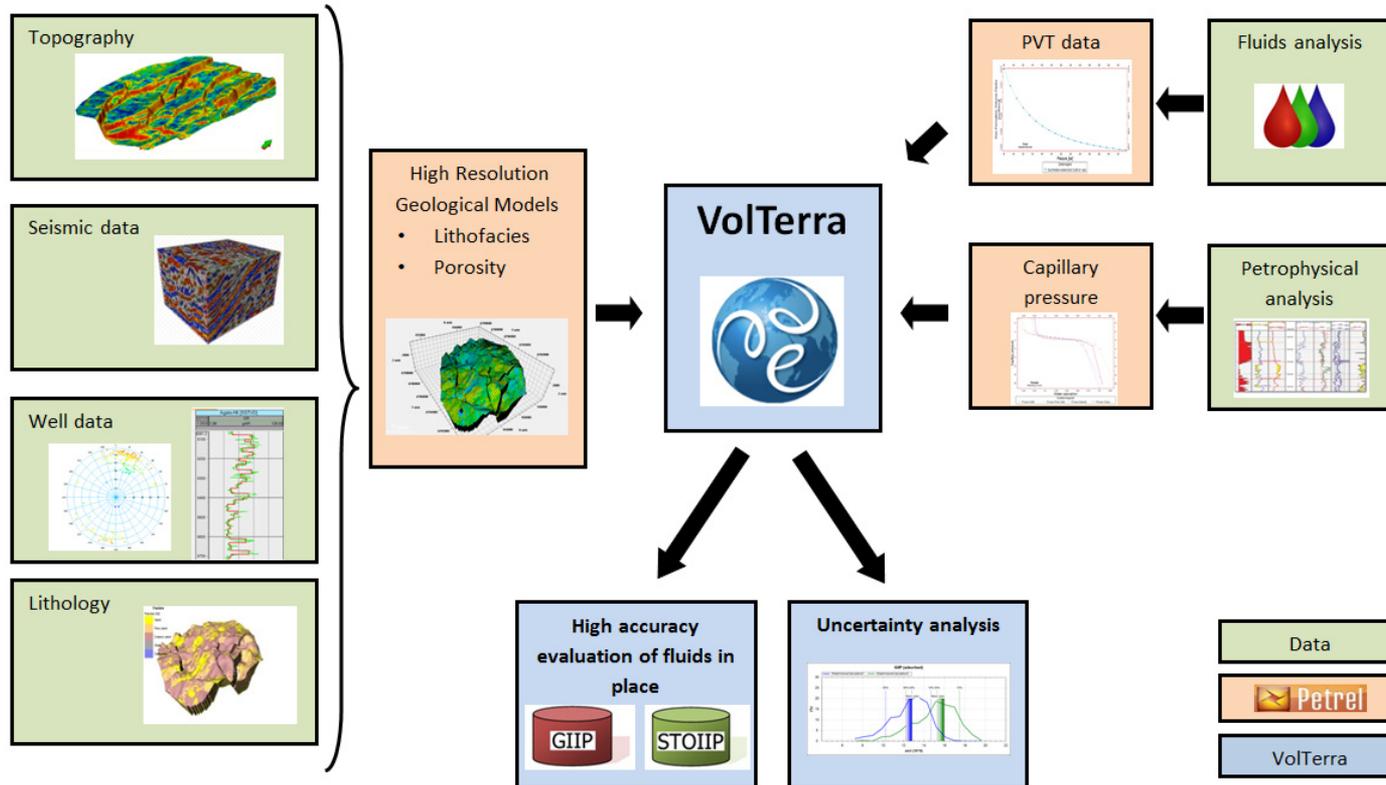
- VolTerra Method
- VolTerra Process
- Requested data
 - High resolution geological model
 - Thermodynamic data
 - Capillary pressure curves
- STOIP & GIIP
- Case study
- Integrated workflow
- Conclusions

VolTerra Method

- Calculations rather than estimations of fluids (oil, gas and water) in place
 - Using right physics of the phenomena
 - On high resolution geological models
 - Before losing resolution due to upscaling
 - Gravity forces and capillary forces in porous media

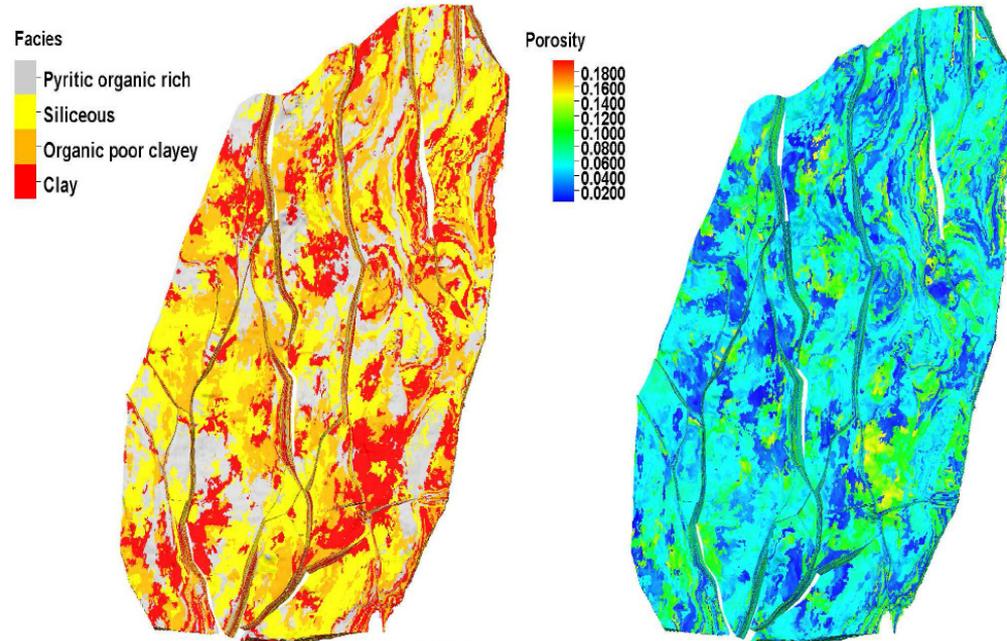
- Hydrocarbon volumes depends on
 - Rocks properties
 - Fluid properties
 - Rocks fluids interactions

VolTerra Process



Requested Data - High Resolution Geological Model

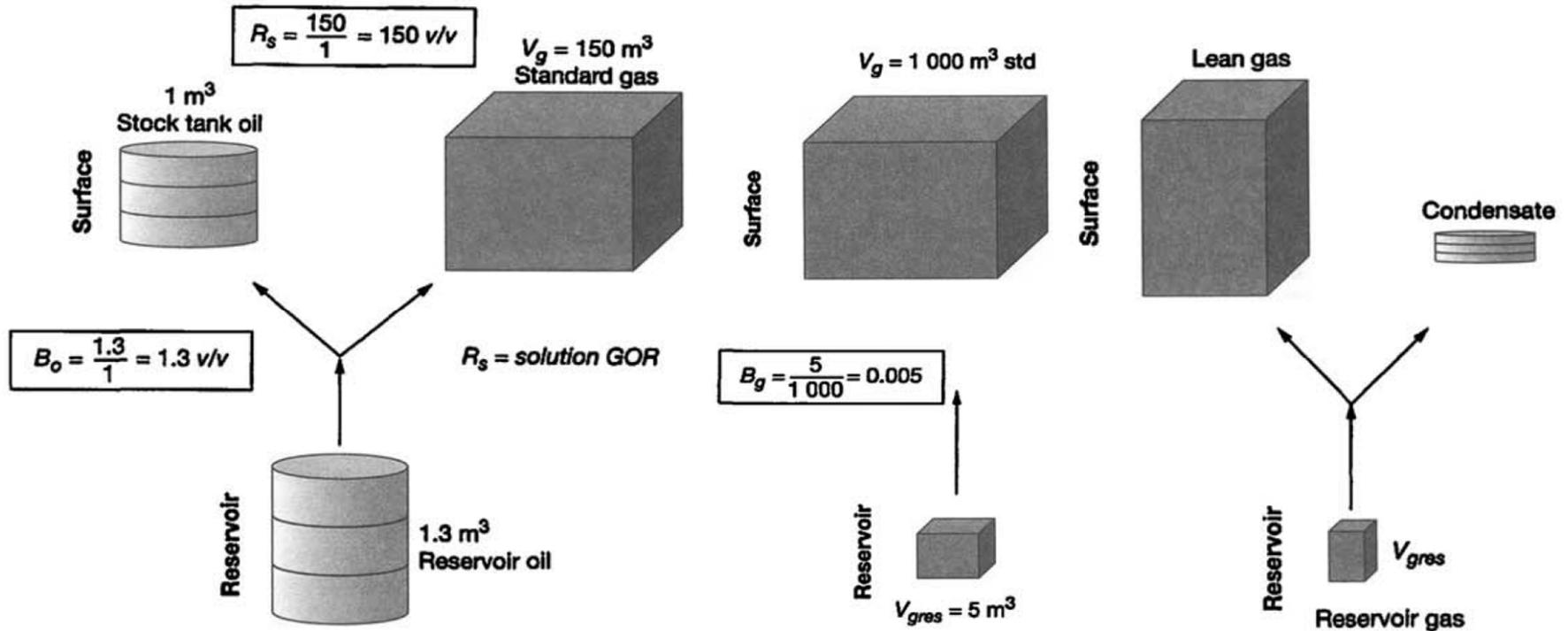
- 3D geological model described in
 - Lithofacies
 - Porosity
 - Net-to-gross (optional)



Requested Data - Thermodynamic Data

- Densities, volume factors and solution ratios of existing phases (Oil, Gas and Water)
 - ρ_g, ρ_o, ρ_w
 - B_g, B_o, B_w
 - R_s : Solution gas-oil ratio
 - R_v : Vaporized oil-gas ratio

Requested Data - Thermodynamic Data



Fluids relationship (Donnez, 2007)

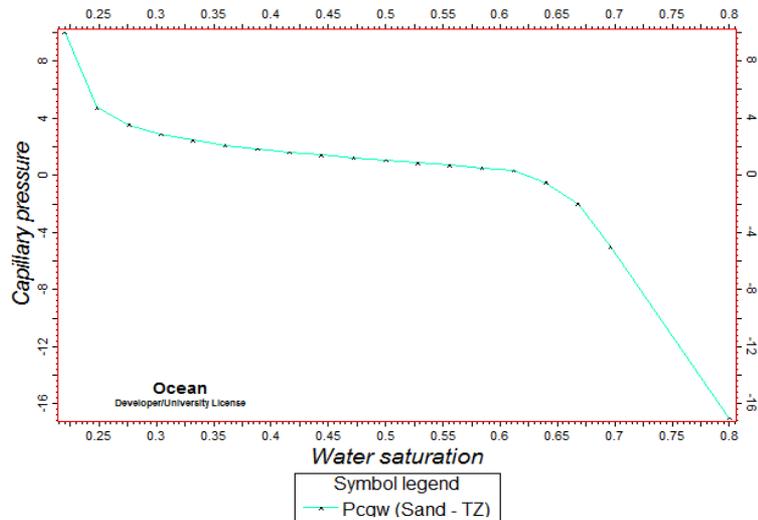
Requested Data - Capillary Pressure Curves

- Capillary pressure:

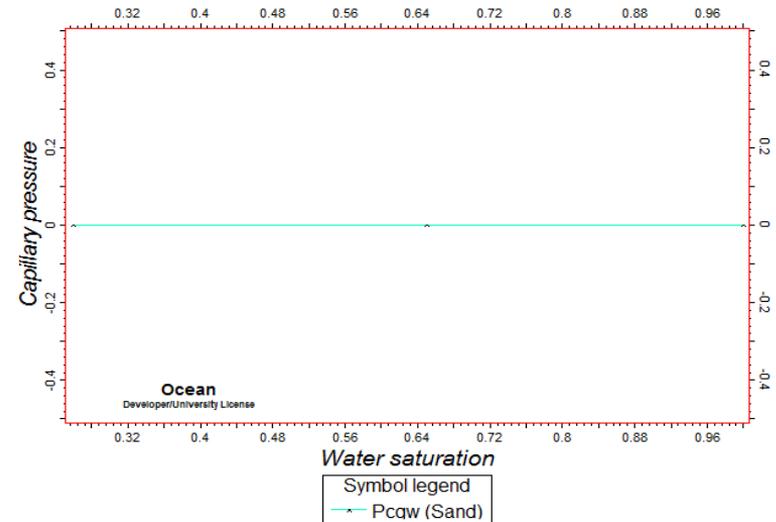
$$P_{cgw} = P_g - P_w$$

$$P_{cow} = P_o - P_w$$

$$P_{cgo} = P_g - P_o$$



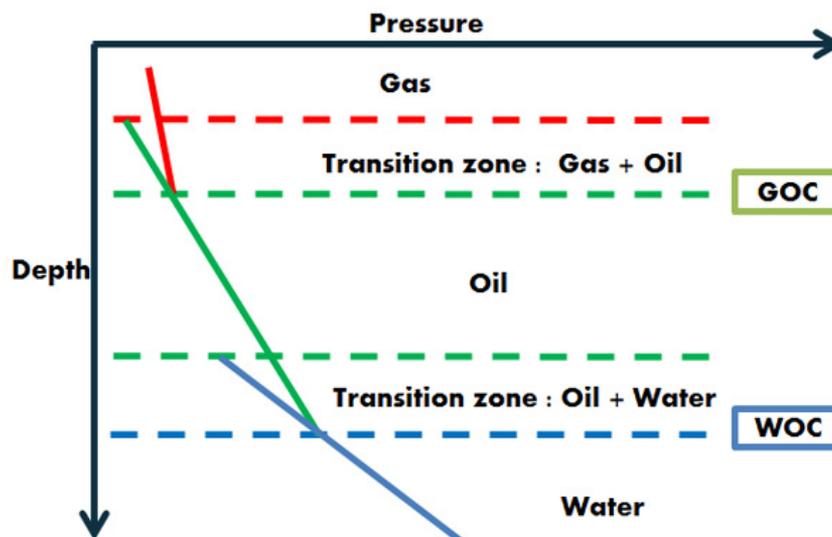
Case with transition zone



Case without transition zone

VolTerra: Free Oil and Gas Calculations

- From PVT data and an initial condition (a pressure at a given depth)
 - Initial equilibrium is computed
 - Fluids present in the reservoir tend to stratify according to their density



VolTerra: Free Oil and Gas Calculations

- Compute the pressure of each phase

$$\frac{dP_o}{dh} = \rho_o(P_o, R_s) \times g, \quad \frac{dP_g}{dh} = \rho_g(P_o, R_v) \times g, \quad \frac{dP_w}{dh} = \rho_w(P_o) \times g,$$

- Compute saturation from capillary pressure between phases

$$P_{cog} = P_g - P_o, \quad P_{cow} = P_o - P_w, \quad P_{cgw} = P_g - P_w$$

- Volume of free oil and gas in this cell is

$$STOII P^i = \frac{S_o^i V_i \phi_i}{B_o^i}$$

$$GIIP_{free}^i = \frac{S_g^i V_i \phi_i}{B_g^i}$$

Processes

Plug-ins
Terra 3E - Volumetrics

- VolTerra
- Shale Volumetrics
- Define Langmuir Adsorption Isotherm

Input

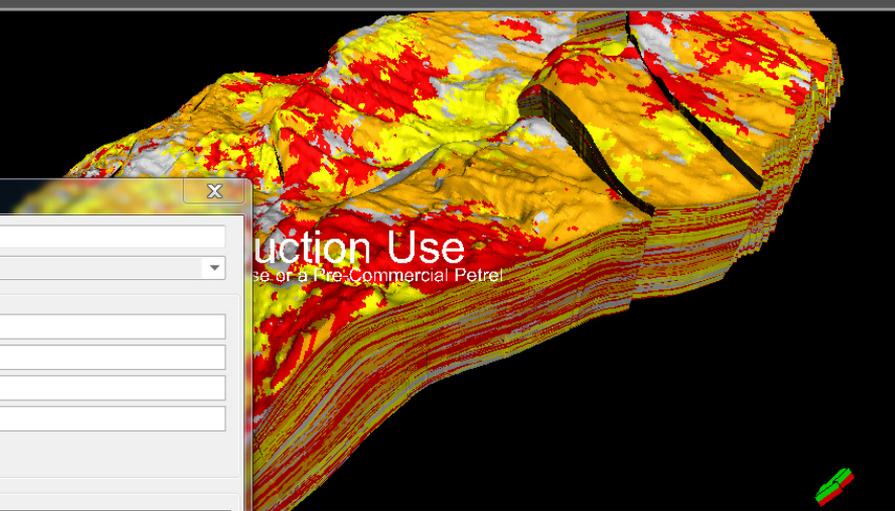
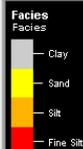
- Wells
- Well Tops
- Fluids
 - Light oil + gas
 - Shale Gas
 - Condensate gas
- 3D Seismic Lines (Time)
- Gullfaks Input
- Uncertainty input
- Rock physics functions
 - Clay
 - Sand
 - Silt
 - Fine Silt
 - Shales
- Langmuir Adsorption Isotherm
- Average
- Optimistic
- Pessimistic

Input Results Templates

Models

- Velocity models
- Gullfaks_Geo
- Copy of HR model
 - Fault model
 - Gullfaks (Skeleton)
 - Gullfaks (HR)
 - Skeleton
 - Faults
 - Horizons
 - Edges
 - Intersections
 - Local grids
 - Properties
 - Facies
 - Porosity
 - Fault filter
 - Zone filter
 - Segment filter

Function window 1 x 3D window 2 [Any] x



VolTerra

Create new: VolTerra
Edit existing: TestVolterra

Import Geological Model Data

Grid: Gullfaks (HR)
Facies: Facies
Porosity: Porosity
Net-To-Gross:

Import Facies Properties

Facies Name	Saturation Function
Clay	Clay
Sand	Sand
Silt	Silt
Fine Silt	Fine Silt

Import Fluid Properties

Fluid functions: Light oil + gas
Initial conditions: Contact Set

Cutoffs

Porosity: 0 %
Water saturation: 100 %

Run Apply Ok Cancel

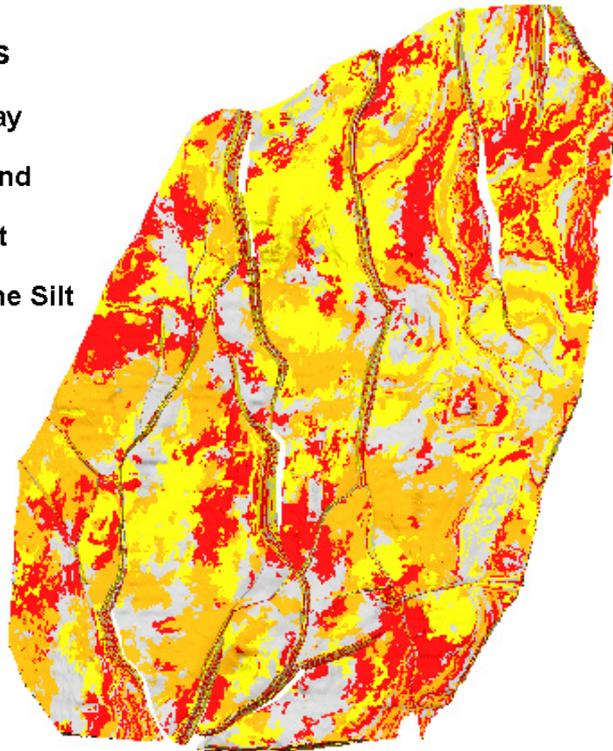
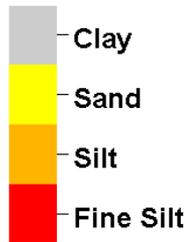
1. Start the process
2. Import data using the blue arrow
3. Run the calculation
4. Visualize the results

Case Study

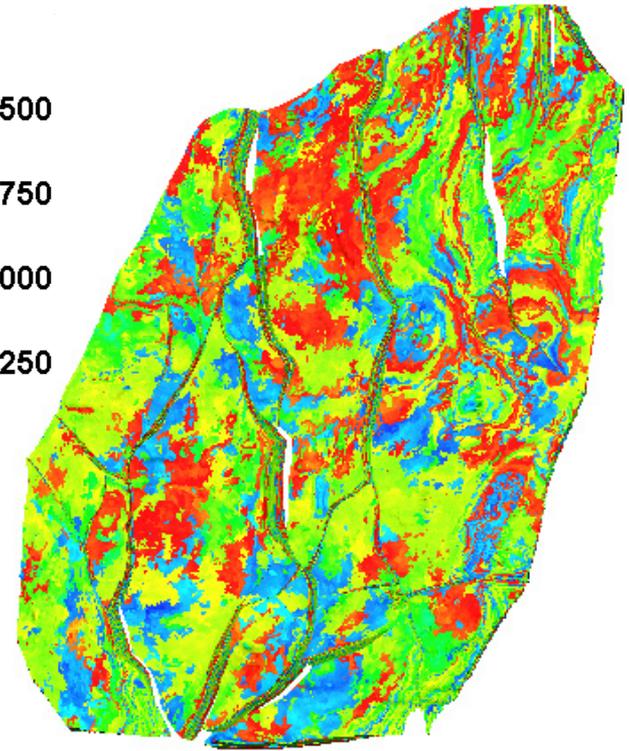
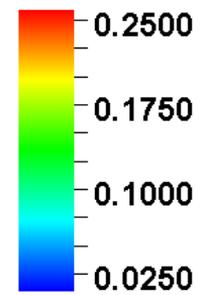
- Synthetic geological model composed of 32.000.000 active cells
- Average cell dimension : 15m x 15m x 1.2m
- 315 layers
- 5 zones
- 4 lithofacies
- Porosity modeling conditioned to the 3D facies realization
- Fluid model : Light Oil + Gas

Case Study

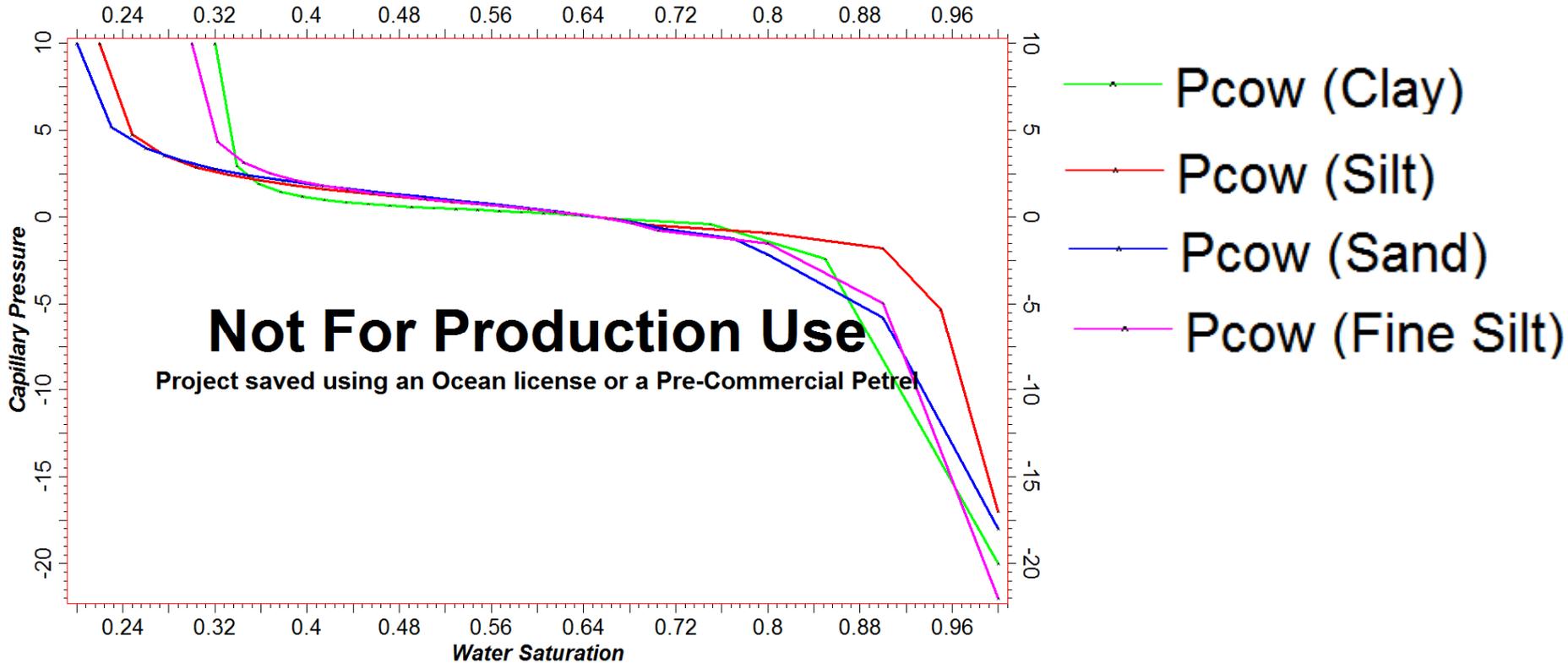
Facies



Porosity

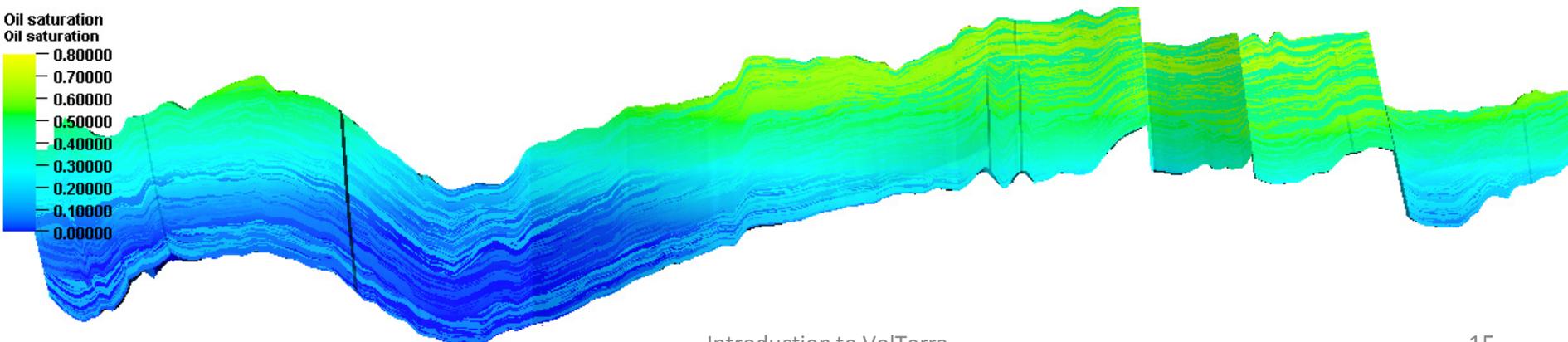


Case Study



Case Study - Results

- STOIIP : $3.2 \cdot 10^8 \text{ sm}^3$
 - STOIIP in oil: $3.2 \cdot 10^8 \text{ sm}^3$
 - STOIIP in gas: 0 sm^3
- GIIP : $7.3 \cdot 10^{10} \text{ sm}^3$
 - GIIP in oil: $4.3 \cdot 10^{10} \text{ sm}^3$
 - GIIP in gas: $3.0 \cdot 10^{10} \text{ sm}^3$



Conclusions

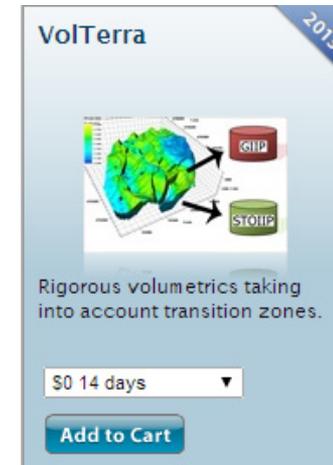
- VolTerra method provides an exact calculation of initial fluids in place
 - On high resolution geological model
 - Without reservoir simulator
 - The calculation speed allows uncertainty estimations
 - 15 minutes for 32 millions cells (Intel Core i5 CPU 2.53GHz)
- Calculations are performed for Black-Oil model
 - With constant or variable bubble point and dew point
- Uncertainty analysis can be done using Petrel workflows
- A full Word report (Data and results) is provided on a click

Licensing & Evaluation

- www.ocean.slb.com



- Free evaluations (14 days)
- 8,000 \$ (12 months)





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