Influence of Transition Zones on Fluids in Place: Application on the Gullfaks Field

Terra 3E SAS

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Outline

- Introduction & Objectives
- Definition
- Requested data
- Application on the Gullfaks field

Introduction & Objectives

- Estimation of hydrocarbons in place is one of the priority tasks defining the reserves
- Hydrocarbon volumes depends
  - Rocks properties
  - Fluid properties
  - Rocks fluids interactions
- The objective of VolTerra™ is to calculate the initial fluids in place directly from the high resolution geological models described in term of lithofacies.
- Several cases will be considered depending on the fluid properties (Black Oil with or without variable bubble and dew points)

Definition

- Hydrocarbons in place (Static evaluation)
  - Oil and Gas initial in place (STOIIP, GIIP)

- Reserves (Dynamic evaluation)
  - Hydrocarbon volumes to produce
  - Initial or ultimate reserves

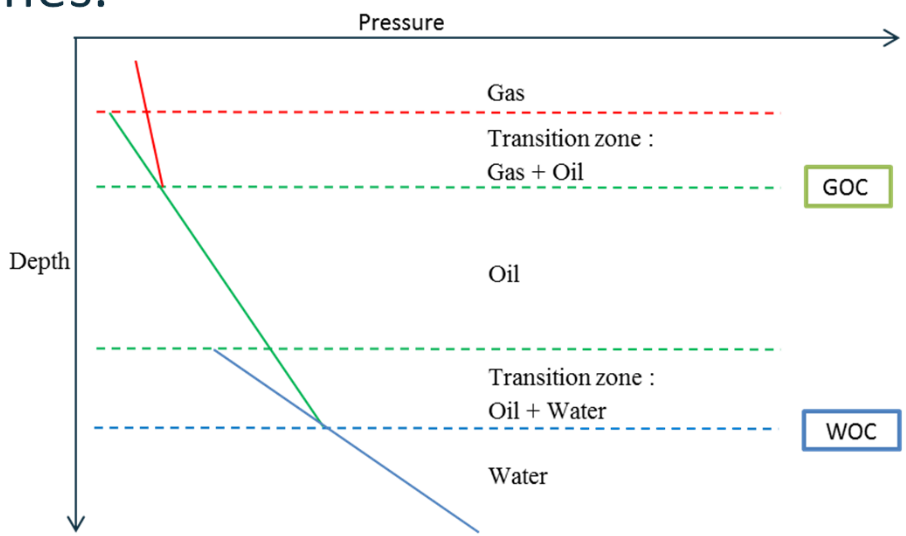
- Recovery factor : Reserves/OIIP

Requested data

- Facies and porosity distribution
- Capillary pressure curves
- Black-oil model for representing the thermodynamic

Capillary pressure curve

- Capillary pressure is the difference in pressure across the interface between two immiscible fluids, it’s a function a saturation and saturation history (drainage or imbibition) for a given reservoir rock and fluids at a constant temperature.
- The role of capillary pressure curves in the initial oil distribution lies in estimation of the saturation of fluids in transition zones.

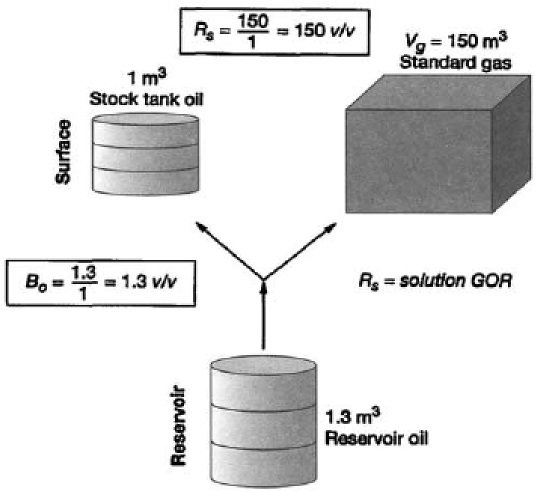


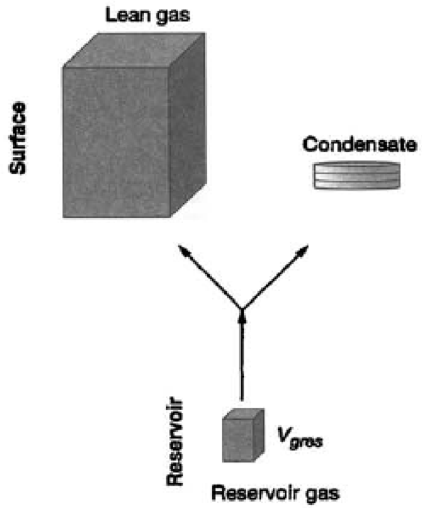
Capillary pressure curve

- Each capillary pressure curve is specific to a facies. Indeed, according to the facies type, the pore size distribution is different, which implies for example, a difference of residual water saturation and residual gas saturation.

Black-oil model for representing the thermodynamic

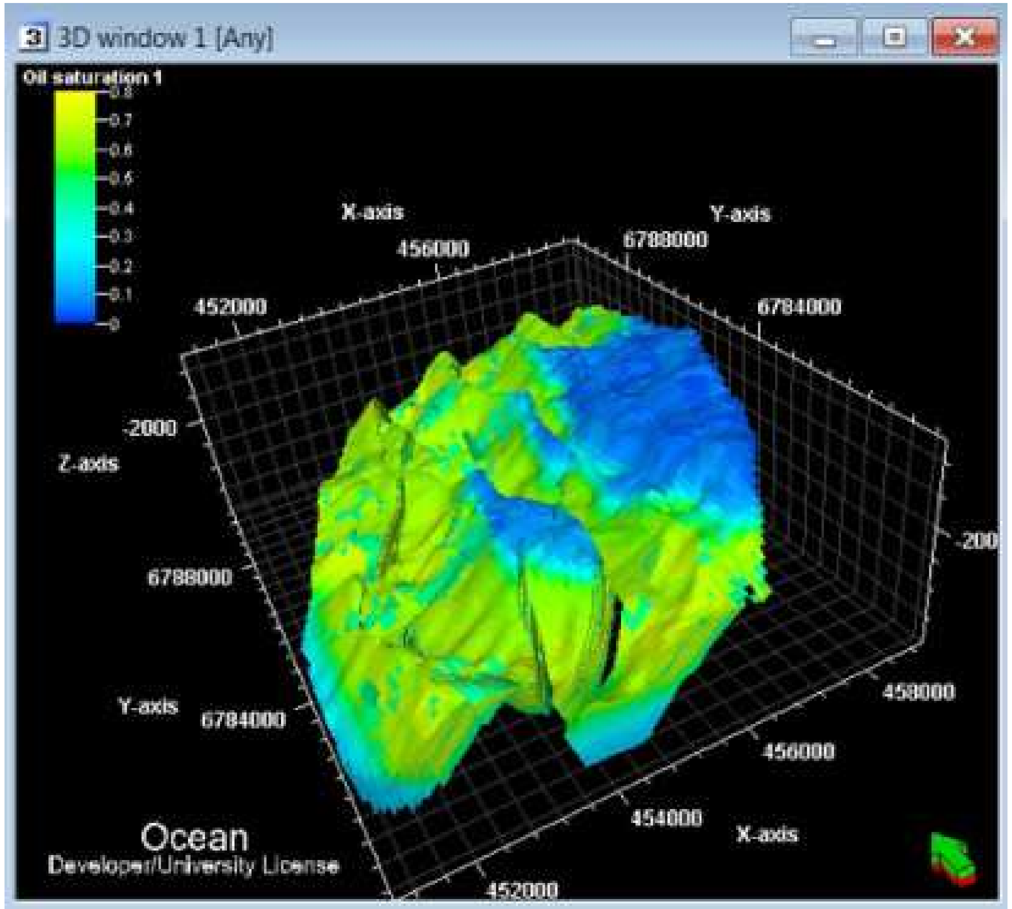
- The Black-Oil model assumes that the reservoir fluids consist of three phases: oil, water, and gas, with gas dissolving in oil and oil vaporizing in gas.
    - The reservoir oil is made of surface oil mixed with a variable amount of surface gas (Rs) in solution.
    - The reservoir gas is made of surface gas mixed with a variable amount of condensate (Rv) in solution





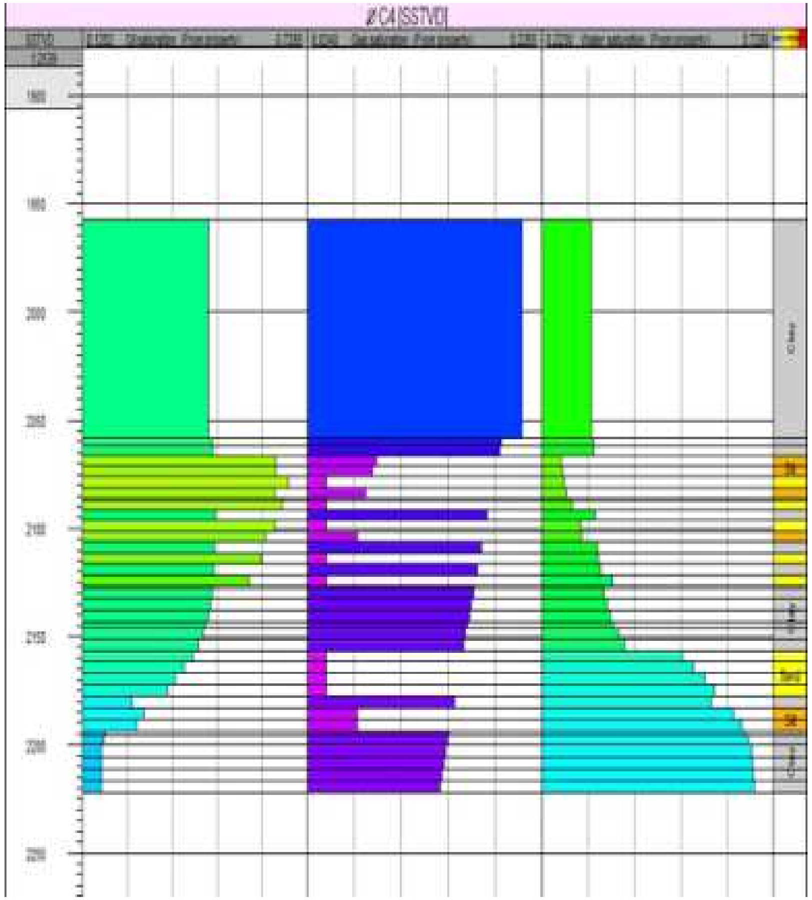
Outputs of VolTerra™

- 3D high resolution saturation & pressure maps



Outputs of VolTerra™

- Saturation profiles along wells (horizontal, vertical & deviated)



VolTerra™

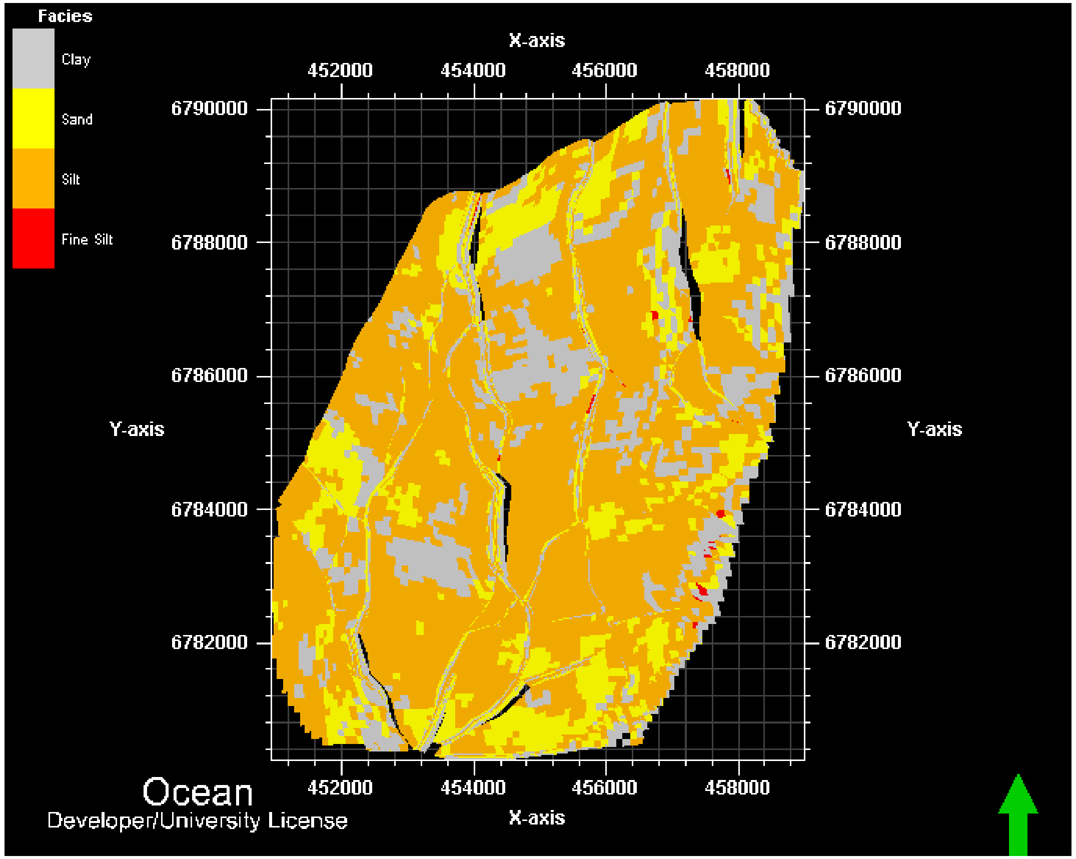
- Same physics & mathematics than in reservoir simulators (Eclipse, VIP, CMG IMEX)
- High space resolution using HR geological models
- Very fast (90s for 1 million cell on a Pc)
- This speed allows uncertainty analysis on multiple scenarios & parameters which the goal of Scenarium™

Example of the Use of VolTerra™

- Gullfaks field
  - http://en.wikipedia.org/wiki/Gullfaks_oil_field
- In block 34/10 in the northern part of the Norwegian North Sea
- Been developed with three large concrete production platforms:
  - A platform began production on 22 December 1986
  - Gullfaks B following on 29 February 1988
  - C platform on 4 November 1989.

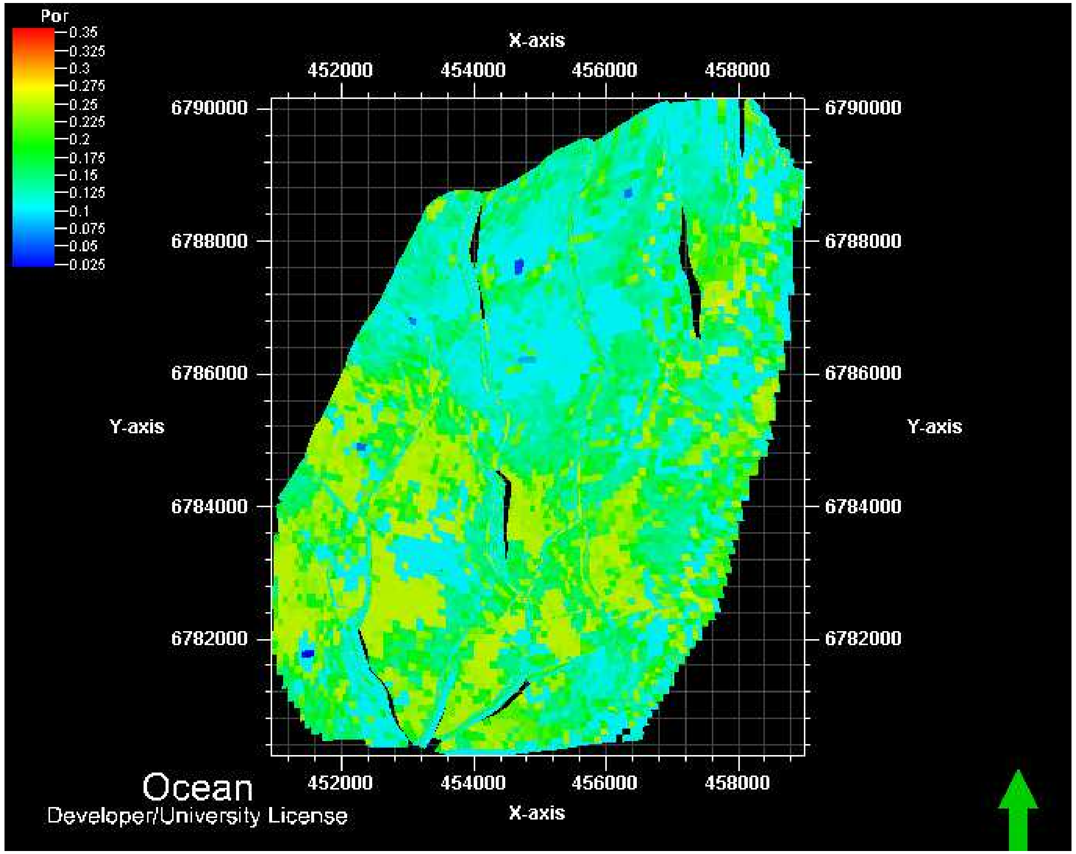
Influence of transition zones on the Gullfaks field

- Geological modeling
  - 471 240 cells
  - Facies grid
    - 4 facies are considered
      - Clay
      - Sand
      - Silt
      - Fine silt



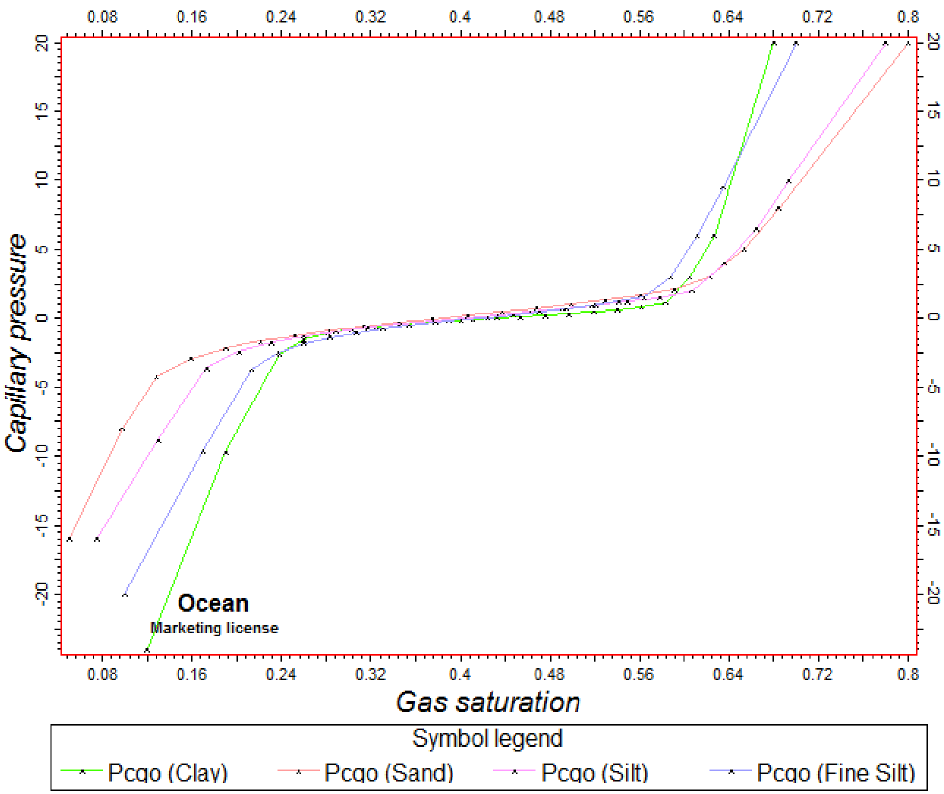
Influence of transition zones on the Gullfaks field

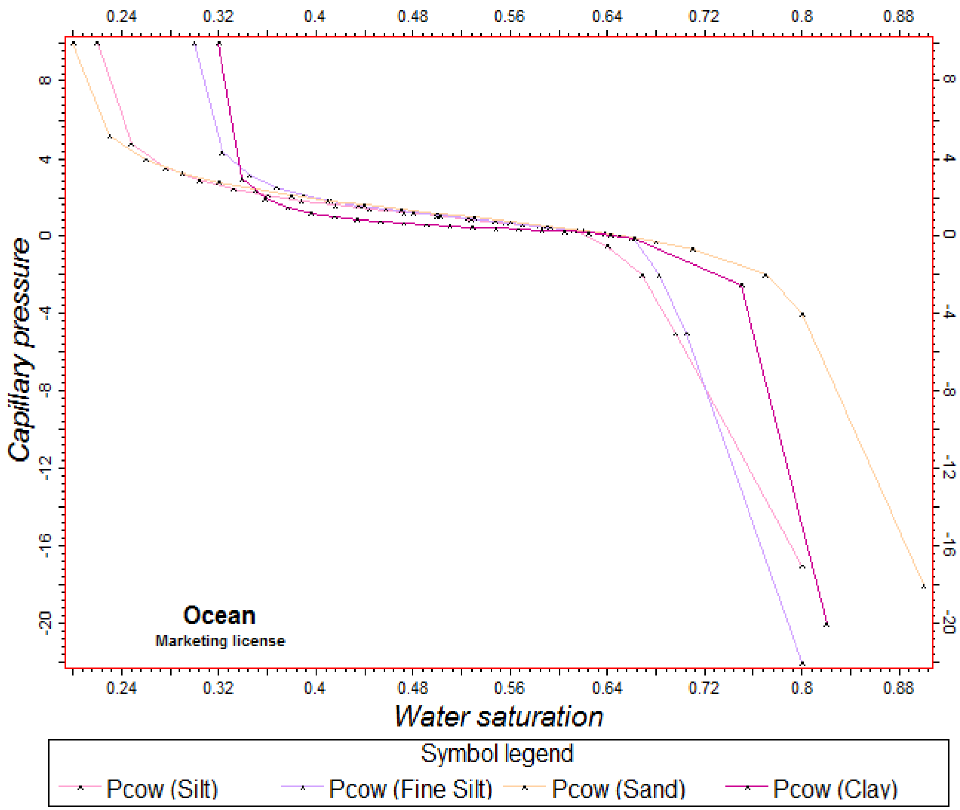
- Geological modeling
  - 471 240 cells
  - Facies grid
    - 4 facies are considered
      - Clay
      - Sand
      - Silt
      - Fine silt
  - Porosity grid



Influence of transition zones on the Gullfaks field

- A capillary pressure curves for each facies





Influence of transition zones on the Gullfaks field

- The thermodynamic data considered here are
  - The fluid model
    - Stock tank oil density : 800 kg/m3
    - Standard gas density : 0.8 kg/m3
    - Water density : 1020 kg/m3
    - Water formation volume factor : 1.01
  - The initial conditions
    - Datum Depth : -1850 m
    - Datum Pressure : 170 bar
    - Gas-Oil Contact Depth : -1850 m
    - Water Contact Depth : -2100 m

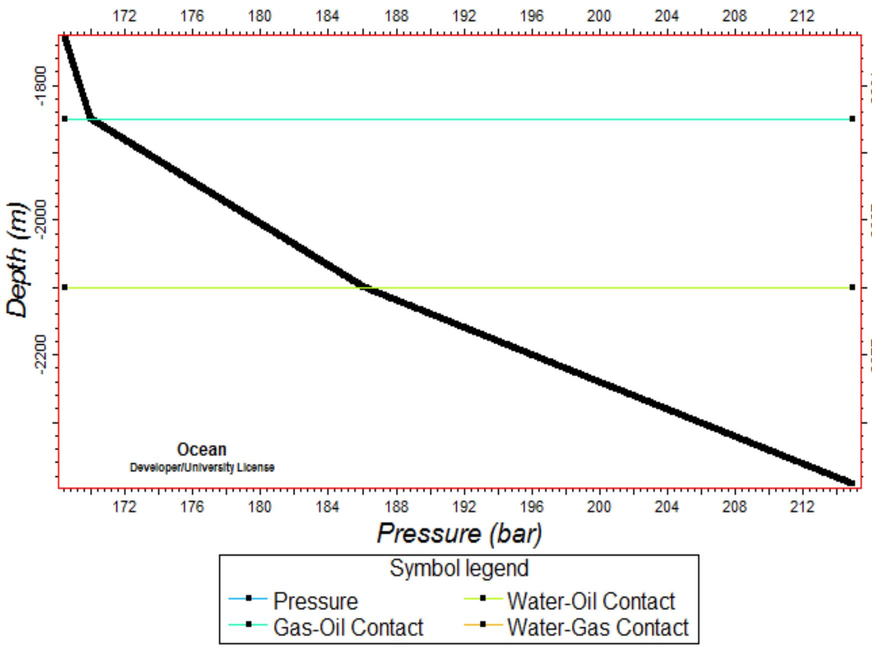
Influence of transition zones on the Gullfaks field

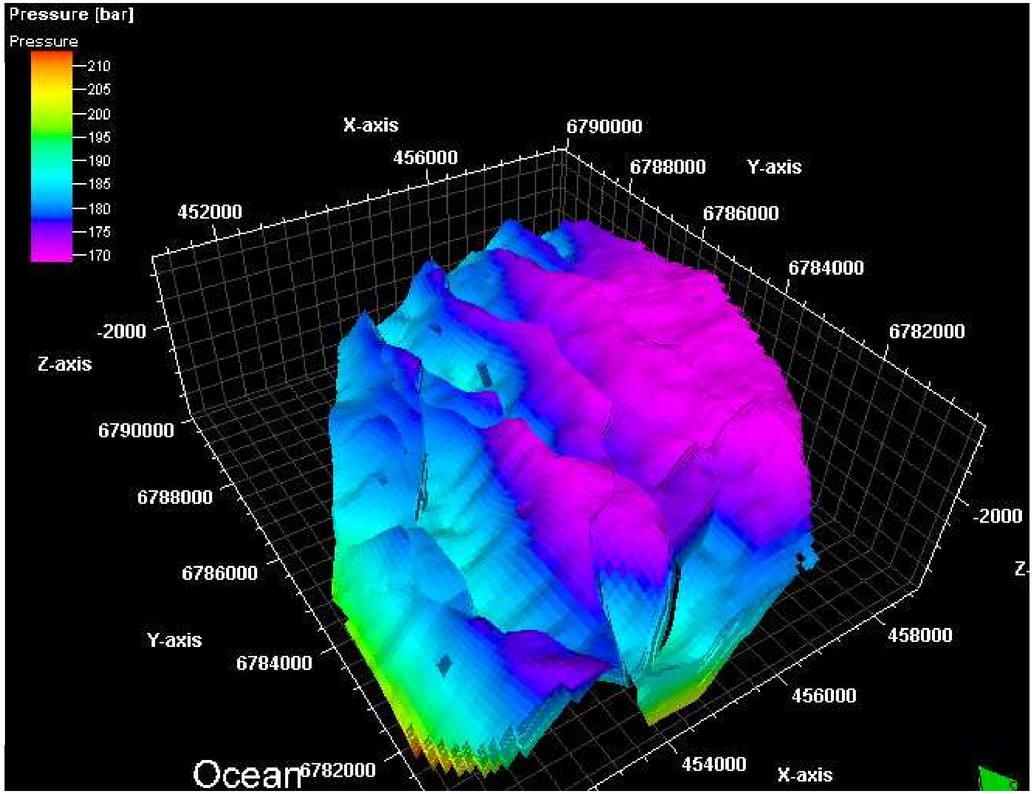
- Two situations will be considered
  - One considering the transition zone : a capillary pressure curve for each facies
  - Another one without transition zone : no capillary pressure curve

- The different results presented shows
  - Variation of reservoir pressure with depth, and maps of the pressure (2D and 3D)
  - Fluid volumes calculated for reservoir conditions and surface conditions
  - The maps of oil, gas and water saturation (2D and 3D)
  - The saturations along three wells

Influence of transition zones on the Gullfaks field

- The initial pressure of the reservoir is calculated from specified initial conditions and PVT data, thus the results of two cases are the same





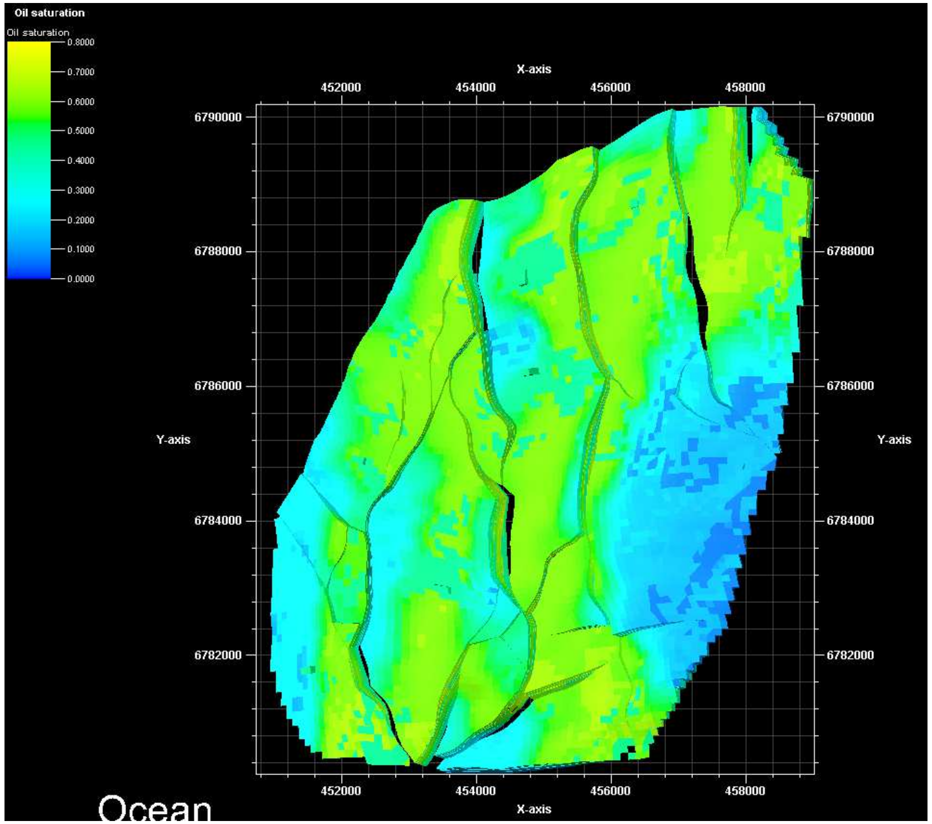
Influence of transition zones on the Gullfaks field

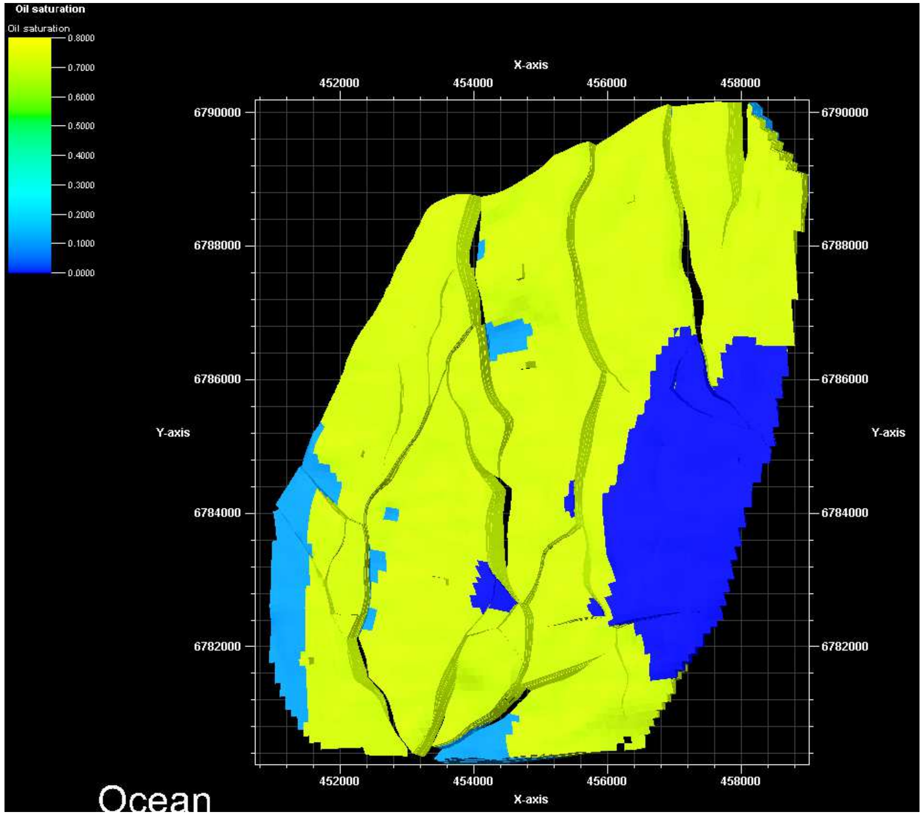
- Fluids in place
  - with transition zone : a capillary pressure curve for each facies (Left)
  - without transition zone : no capillary pressure curve (Right)

	With Transition Zone	Without Transition Zone
STOIIP	3.03e+08 sm3	3.83e+08 sm3
STOIIP (in oil)	3.03e+08 sm3	3.83e+08 sm3
STOIIP (in gas)	0.00e+00 sm3	0.00e+00 sm3
GIIP	7.02e+10 sm3	6.87e+10 sm3
GIIP (in oil)	4.14e+10 sm3	5.24e+10 sm3
GIIP (in gas)	2.88e+10 sm3	1.64e+10 sm3
Oil (reservoir conditions)	4.20e+08 rm3	5.32e+08 rm3
Gas (reservoir conditions)	1.81e+08 rm3	1.03e+08 rm3
Water (reservoir conditions)	4.83e+08 rm3	4.49e+08 rm3

Influence of transition zones on the Gullfaks field

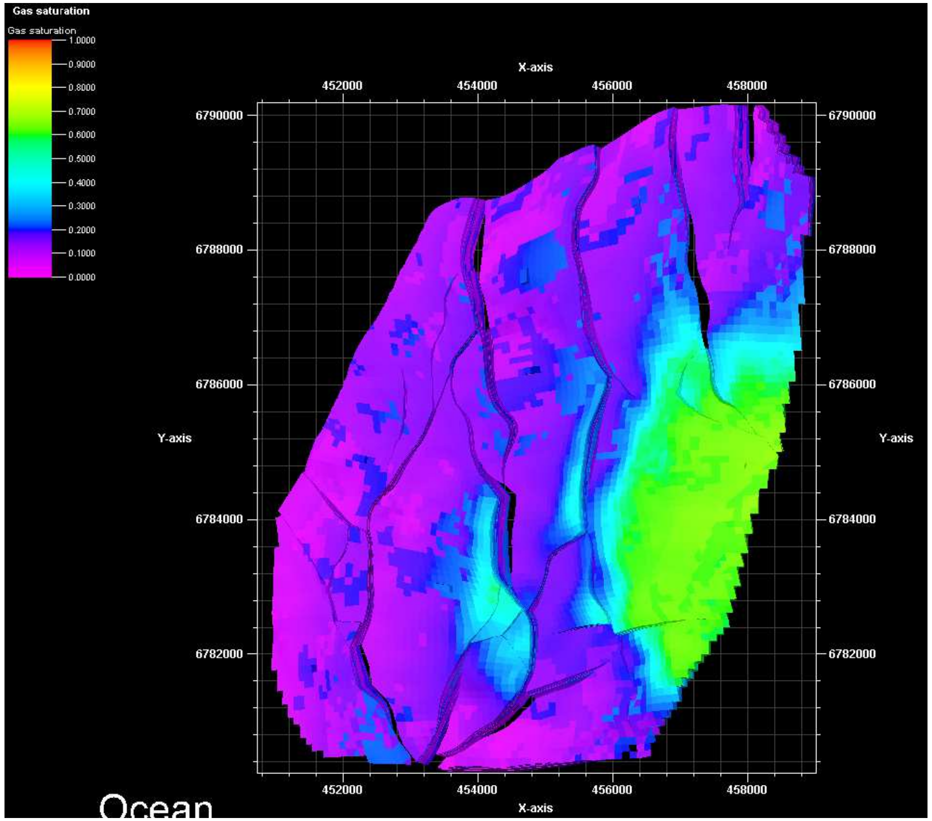
- Oil saturation
  - with transition zone : a capillary pressure curve for each facies (Left)
  - without transition zone : no capillary pressure curve (Right)

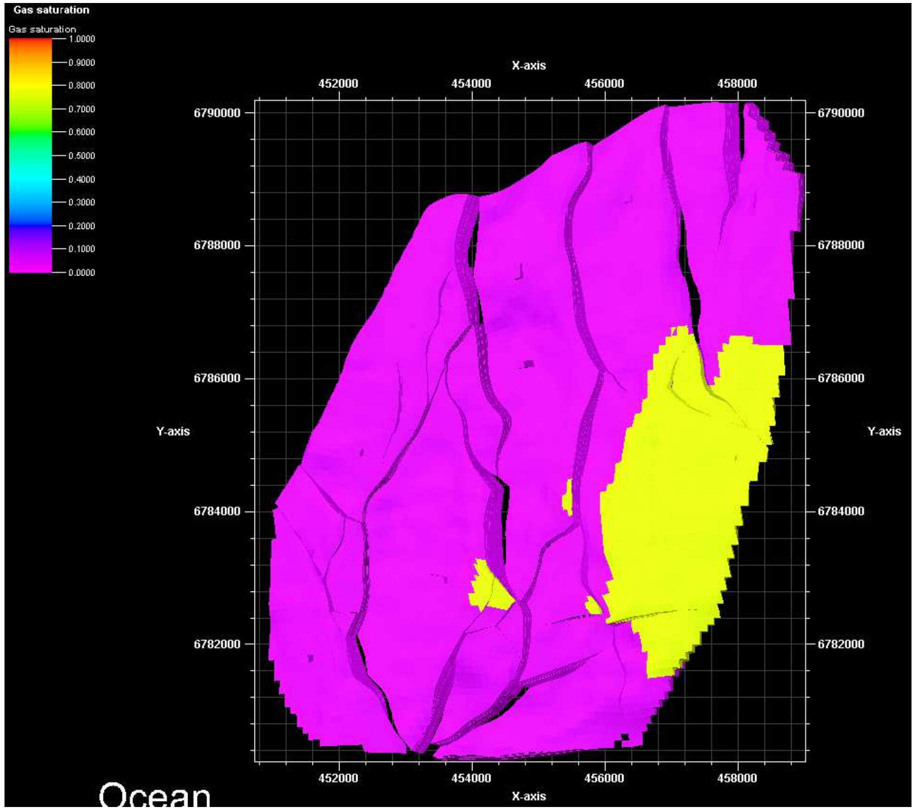




Influence of transition zones on the Gullfaks field

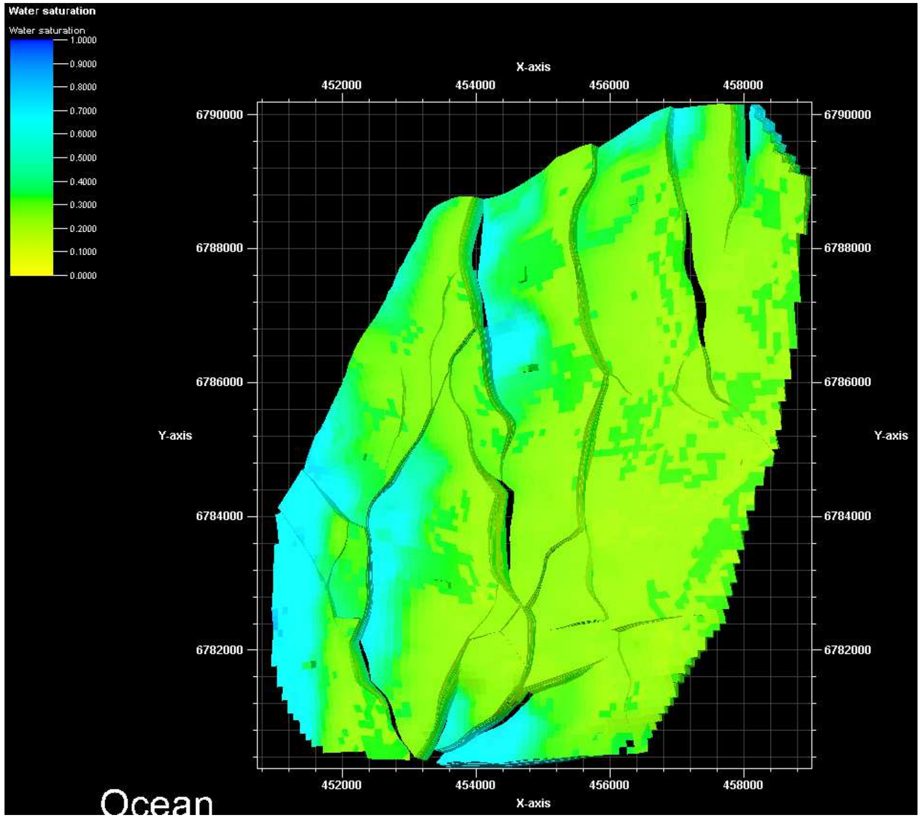
- Gas saturation
  - with transition zone : a capillary pressure curve for each facies (Left)
  - without transition zone : no capillary pressure curve (Right)

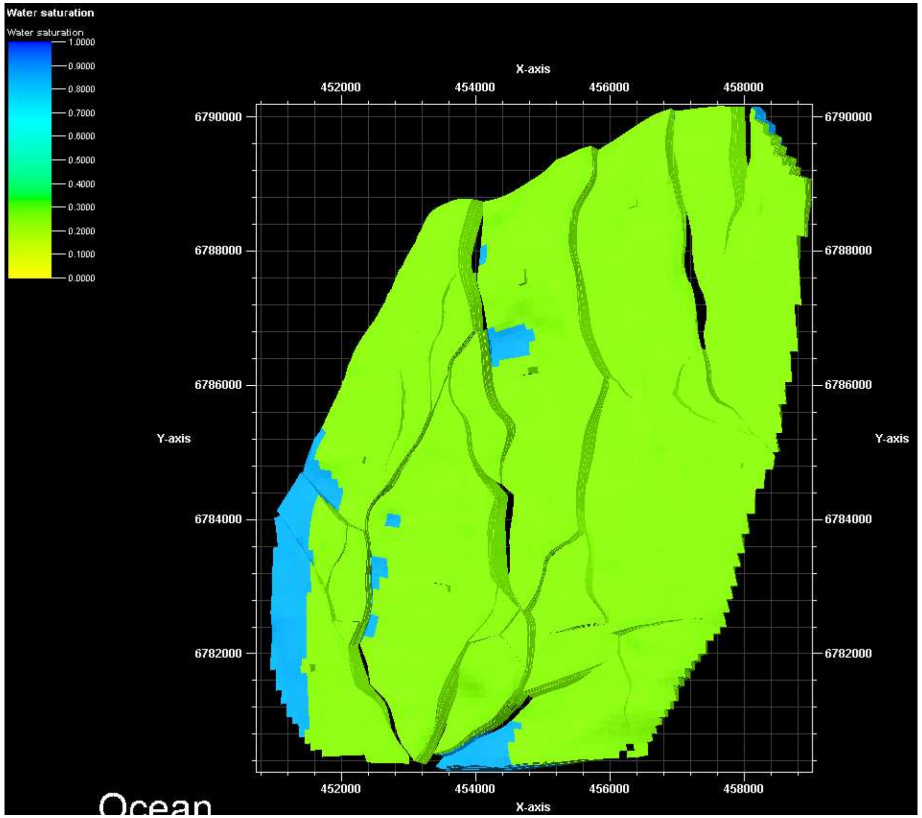




Influence of transition zones on the Gullfaks field

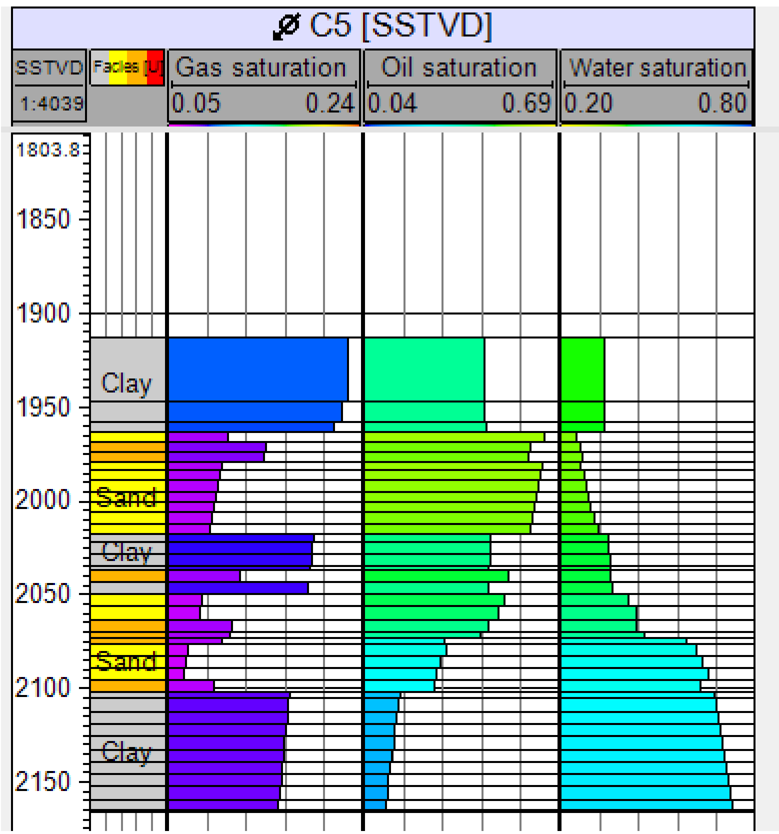
- Water saturation
  - with transition zone : a capillary pressure curve for each facies (Left)
  - without transition zone : no capillary pressure curve (Right)

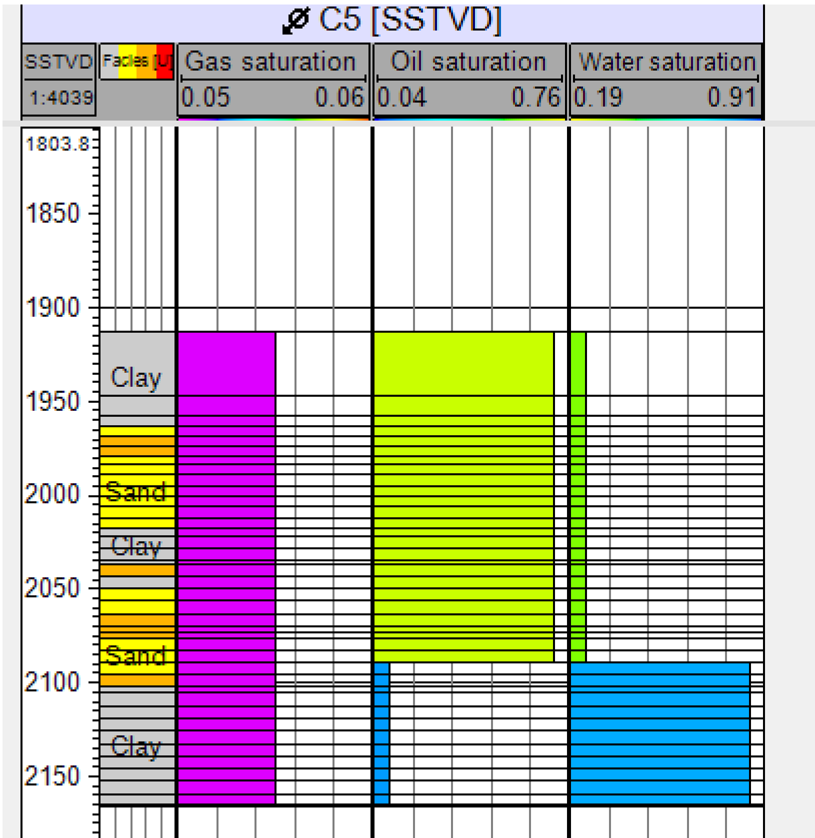




Influence of transition zones on the Gullfaks field

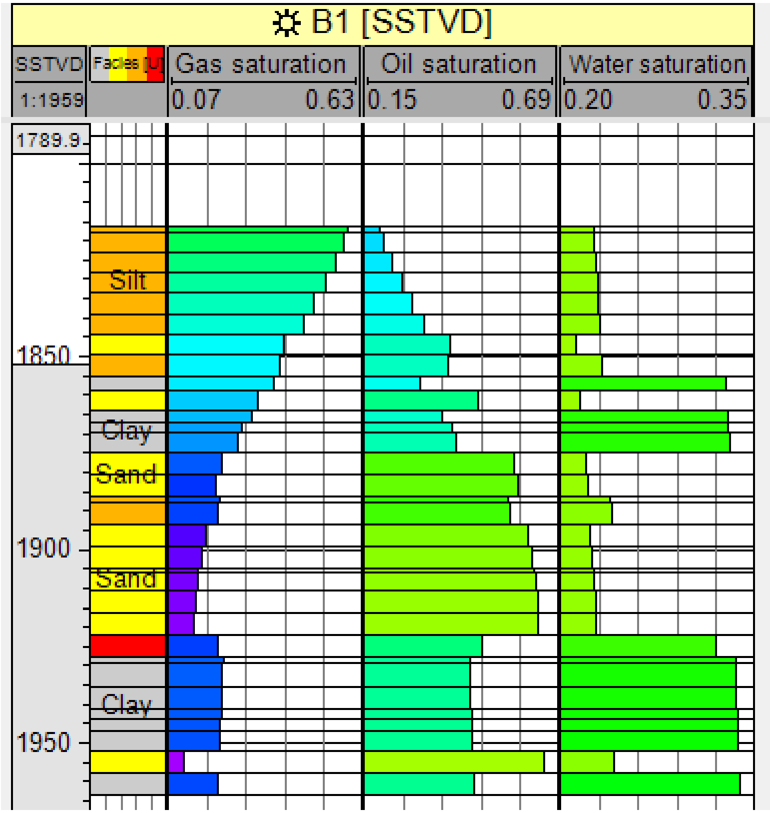
- Saturations along well C5
  - with transition zone : a capillary pressure curve for each facies (Left)
  - without transition zone : no capillary pressure curve (Right)

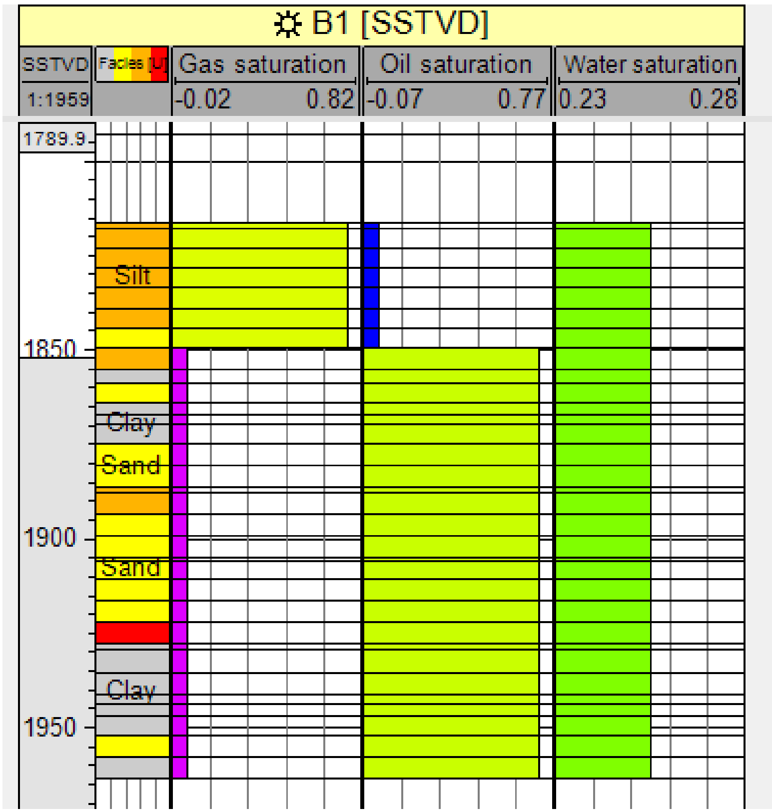




Influence of transition zones on the Gullfaks field

- Saturations along well B1
  - with transition zone : a capillary pressure curve for each facies (Left)
  - without transition zone : no capillary pressure curve (Right)





Influence of transition zones on the Gullfaks field

- A good estimate of saturation around contact areas (Gas-Oil and Water-Oil) requires the use of capillary pressure curves.
- In the case with transition zone, we observe, as expected, a progressive variation of saturation at the contact zones.
- Use capillary pressure to estimate the saturation (and thus volume in place) increases the precision of the results.

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