CO2-EOR and storage by CO2 injection in North Sea formations

by

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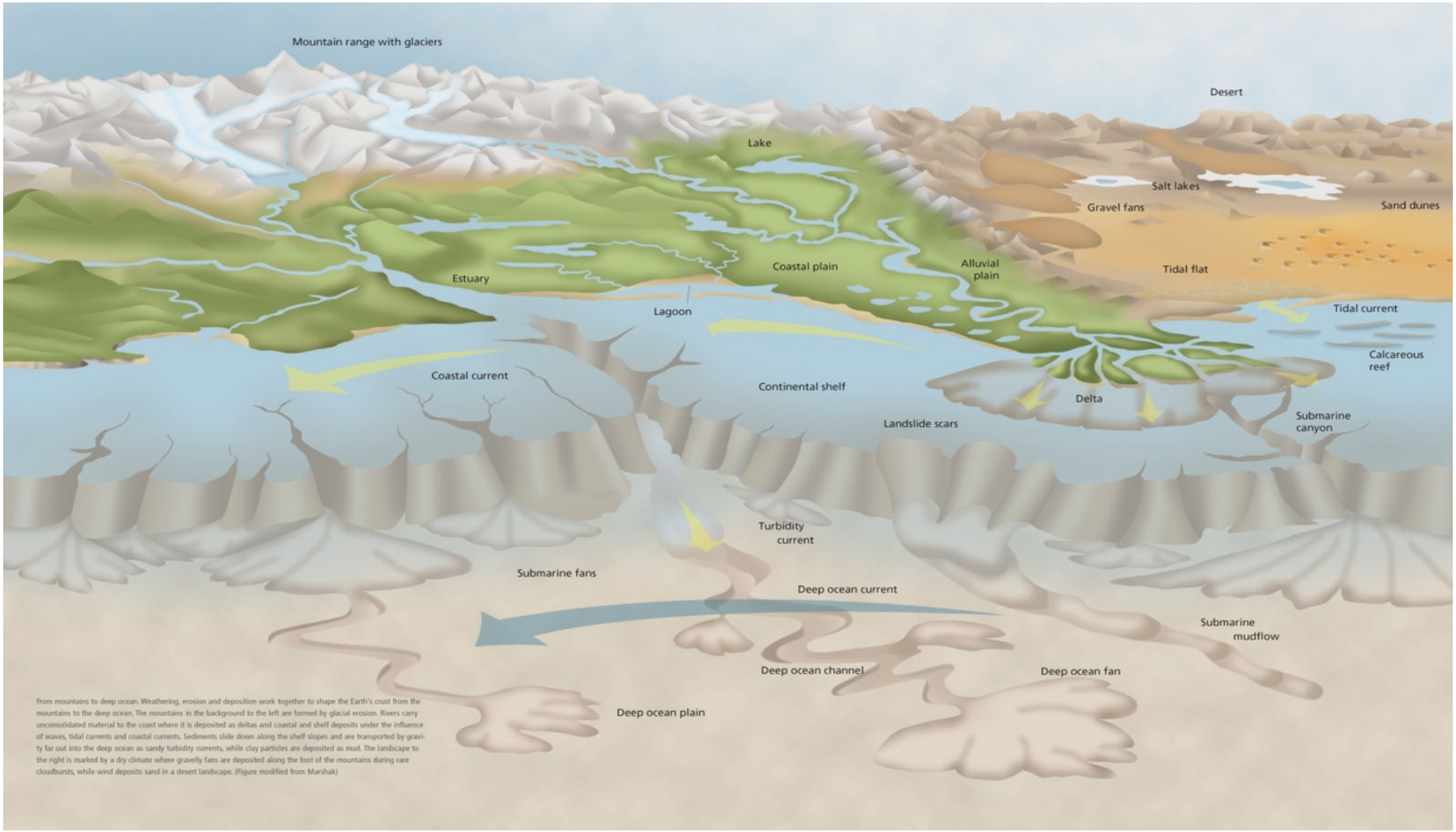
Content

- Selected North Sea oil reservoir deposits
- Construction of reservoir models, fluids and rock properties
- Overview of parameters and reservoir simulation runs
- CO_2 EOR efficiencies in conceptual reservoir models and a field model
- Conclusions

Purpose of the research work

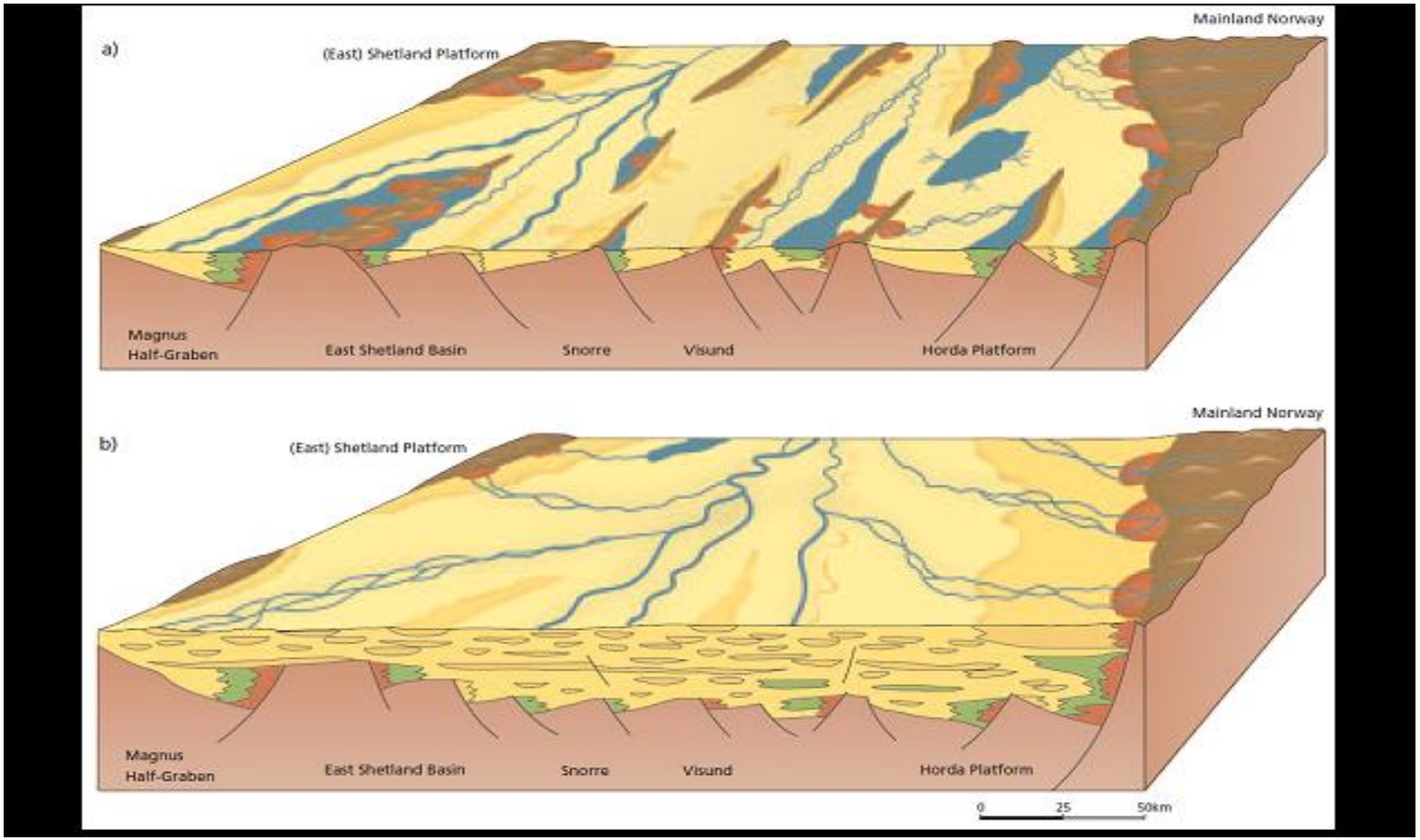
- Quantify the EOR efficiency and CO_2 storage capacity during CO_2 injection in selected water flooded North Sea oil reservoirs

Selected North Sea oil reservoir deposits

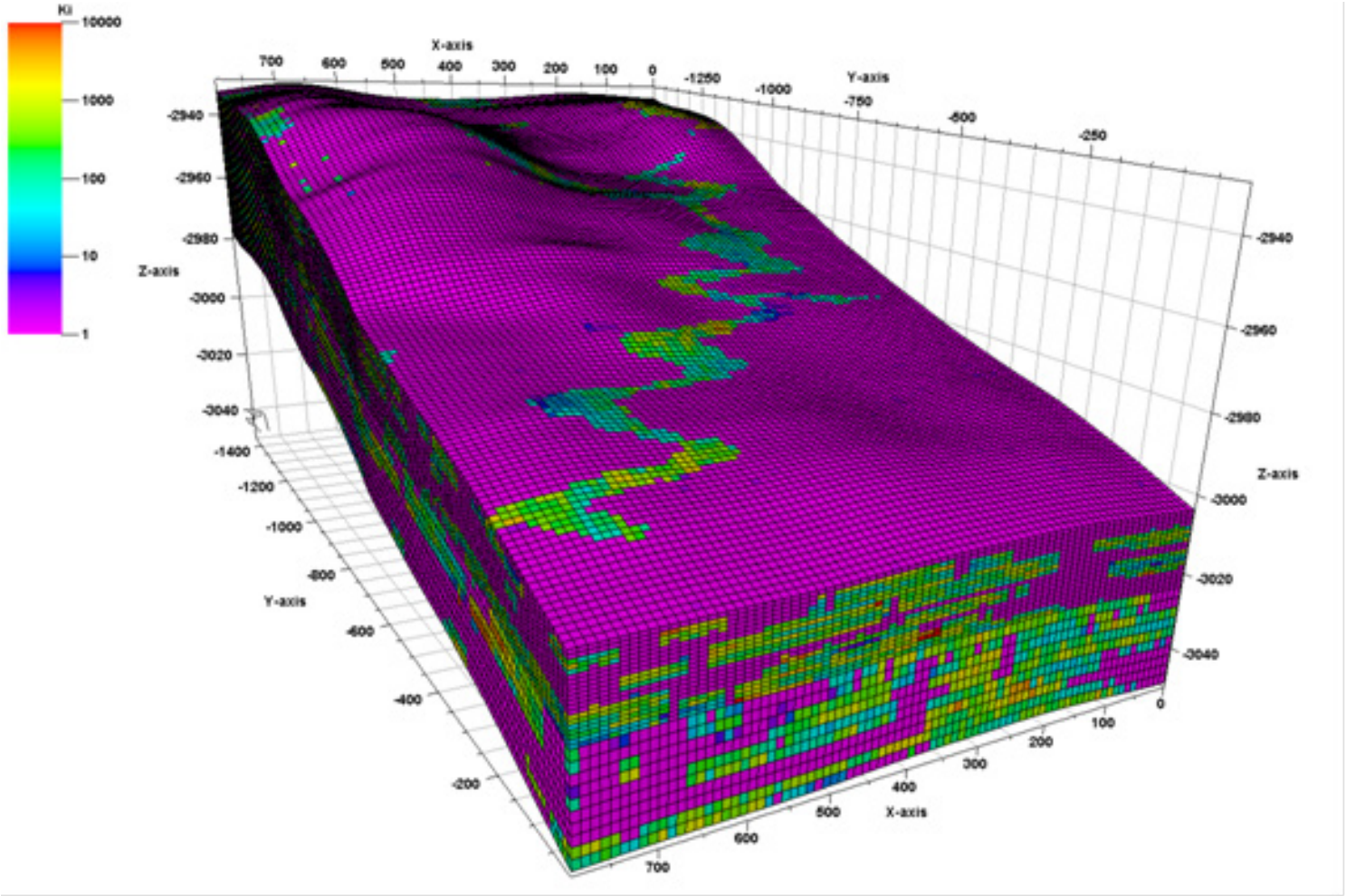


from mountains to deep ocean. Weathering, erosion and deposition work together to shape the Earth's crust from the mountains to the deep ocean. The mountains in the background to the left are formed by glacial erosion. Rivers carry unconsolidated material to the coast where it is deposited as deltas and coastal and shelf deposits under the influence of waves, tidal currents and coastal currents. Sediments slide down along the shelf slopes and are transported by gravity far out into the deep ocean as sandy turbidity currents, while clay particles are deposited as mud. The landscape to the right is marked by a dry climate where gravelly fans are deposited along the foot of the mountains during rare cloudbursts, while wind deposits sand in a desert landscape. (Figure modified from Marshak)

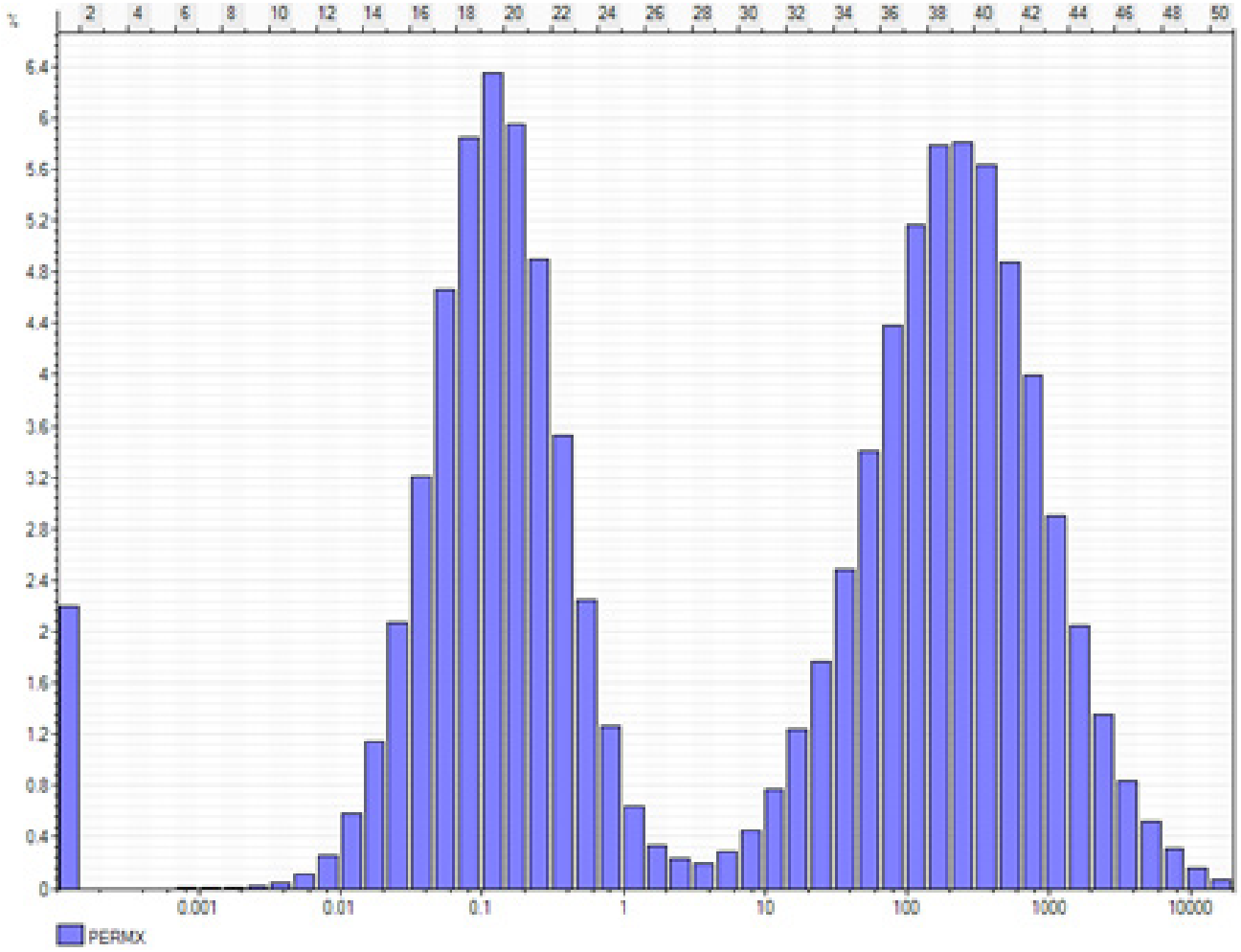
An alluvial plain extended over large parts of the North Sea basin. Reconstructions of the northern basin during Early Triassic (above) as half-grabens and Late Triassic (below) as broad alluvial plain



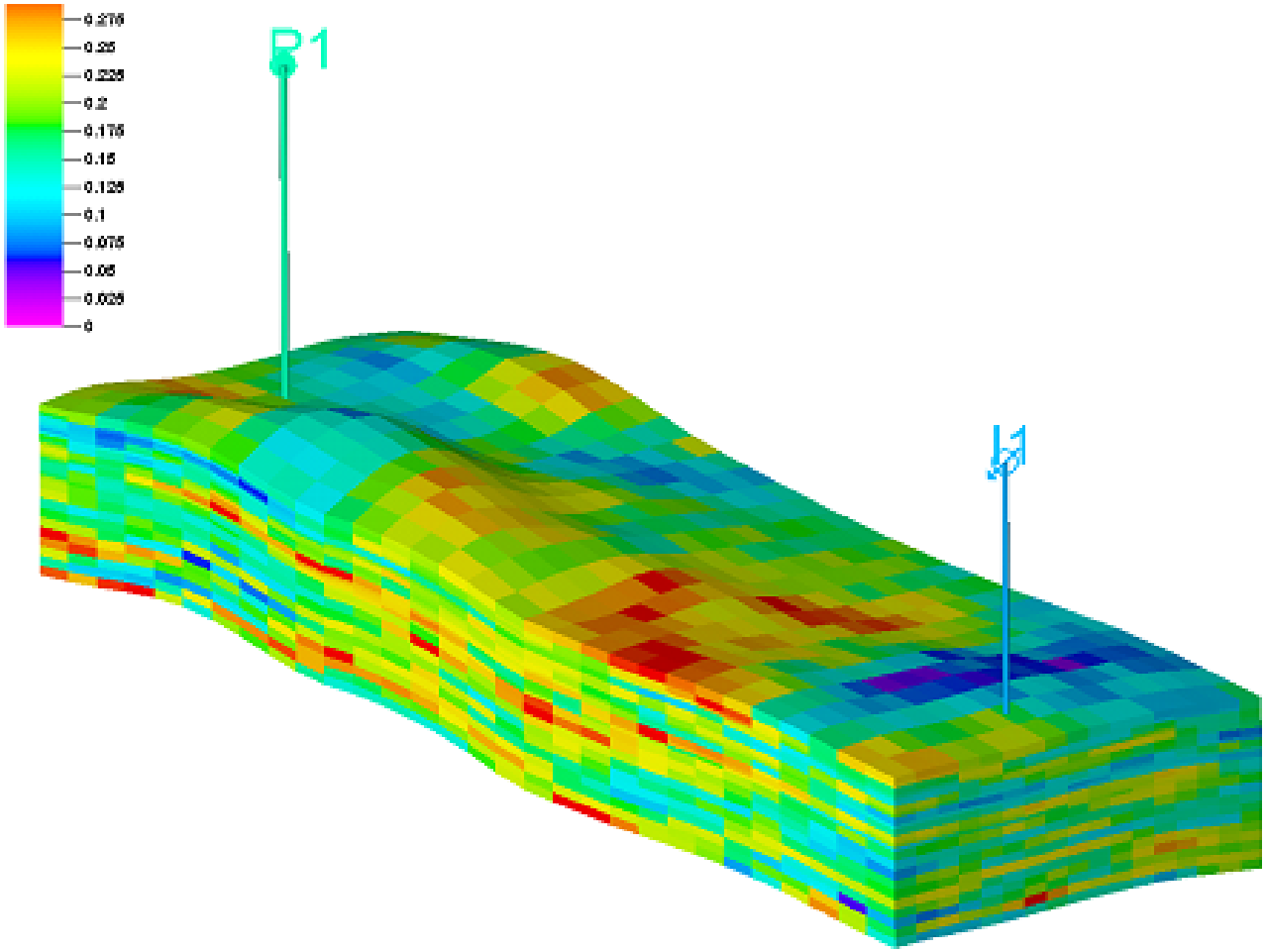
Construction of sector reservoir model; permeability distribution in fluvial deposit



Frequency distribution of permeability in the fluvial deposit model

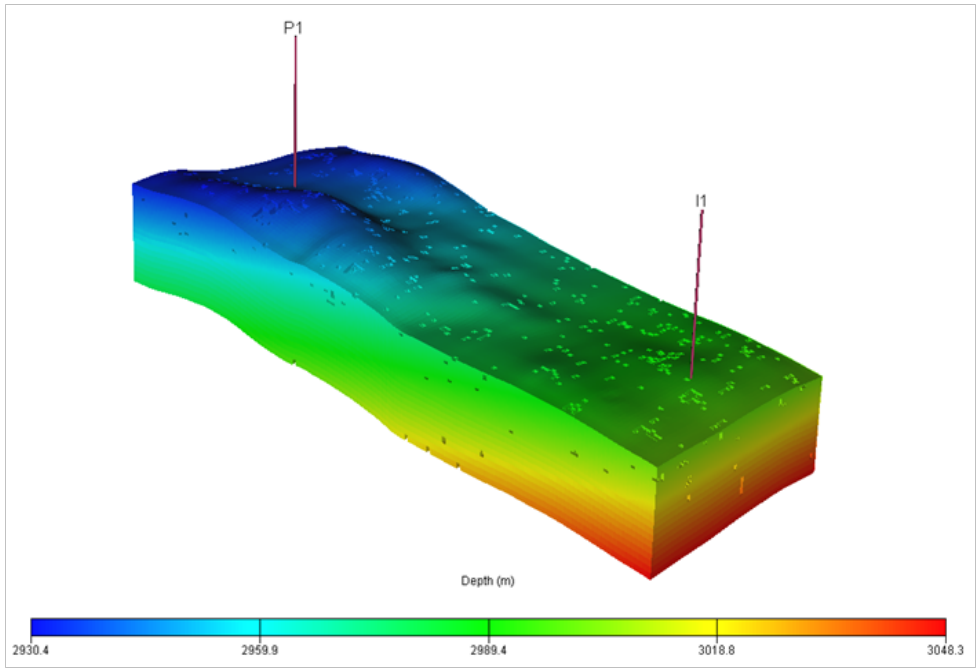


Porosity of the shallow marine North Sea sector model



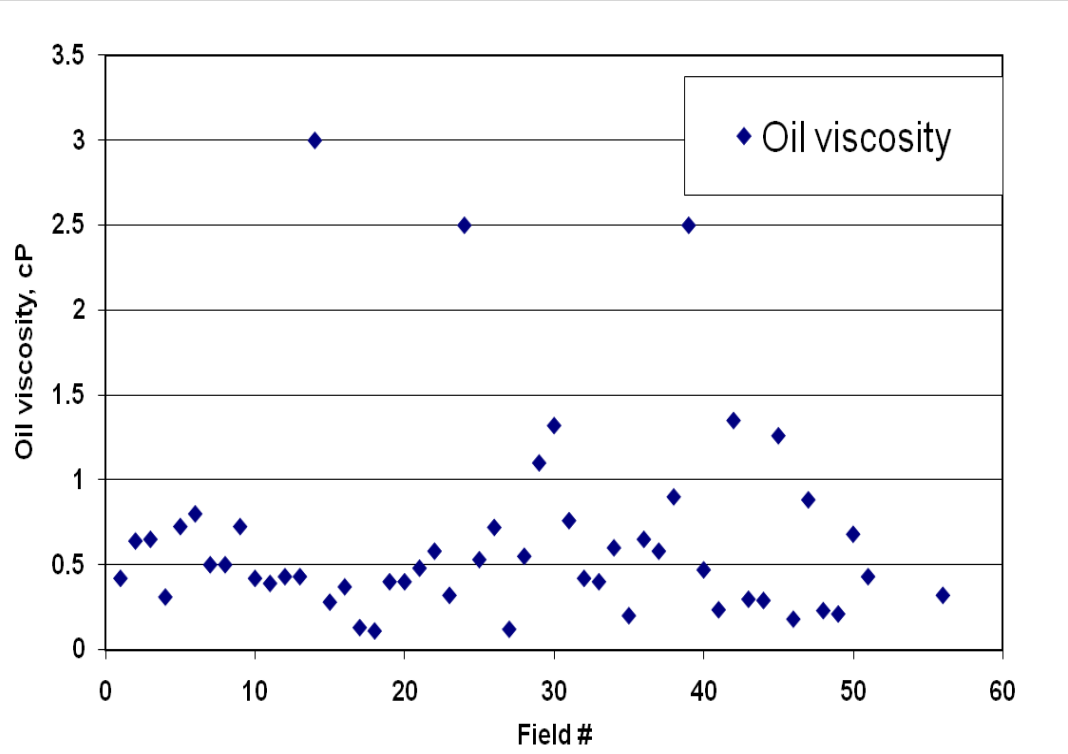
Reservoir simulation sector model size, thickness, grid characteristics, depth and wells

- Size of model:
  - Areal extent 790 x 1450 m
  - Thickness 46 ± 1.2 m
- Grid blocks:
  - Number of grid blocks: 79 x 144 x 30 (~340 000)
  - Resolution 10 x 10 m
  - Average thickness ~1.5 m
  -
- Two wells
  - One injector and
  - One producer

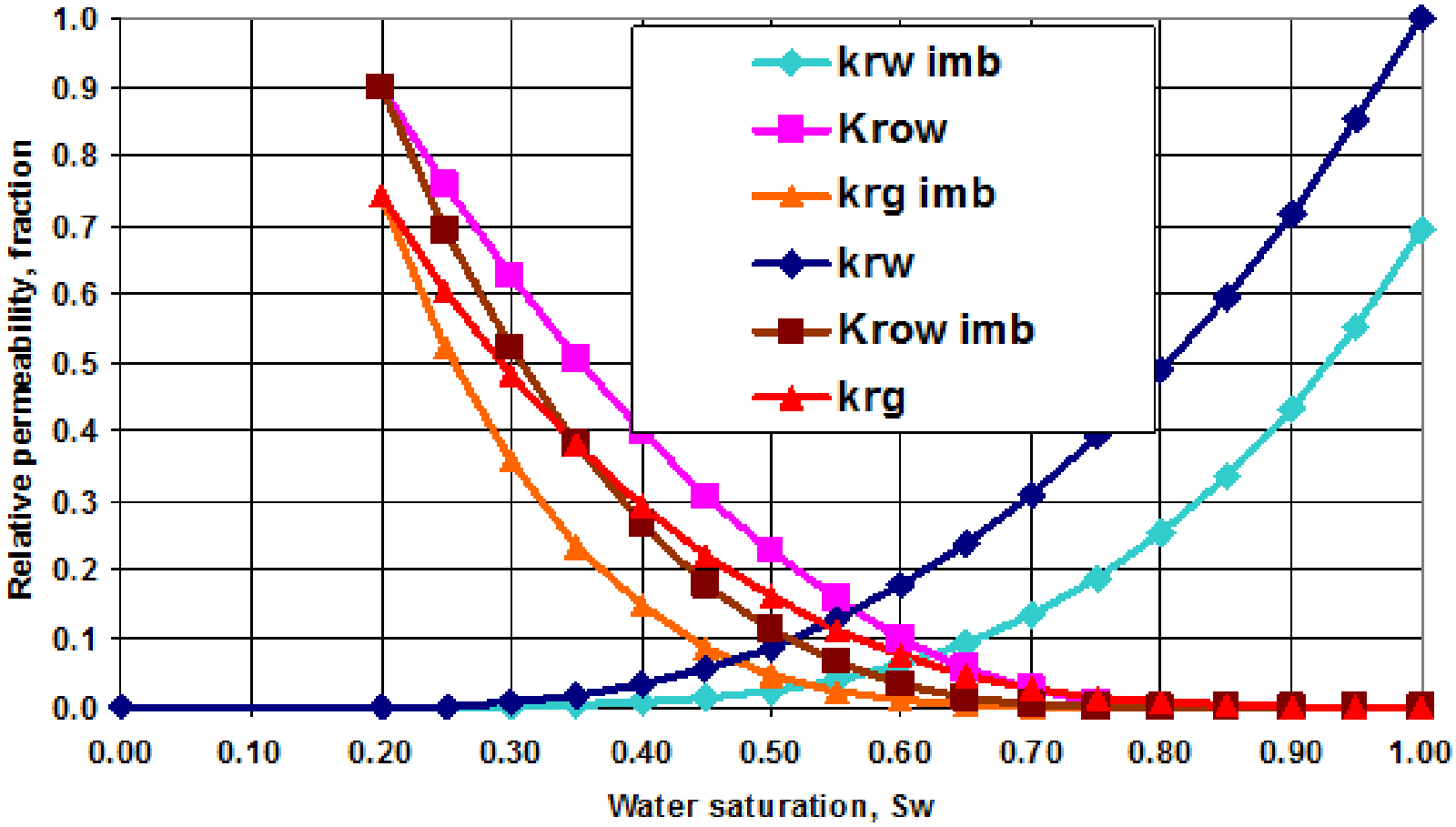


Fluid properties of some 50 selected water flooded oil reservoirs considered potential candidates for CO_2 injection in the North Sea

The molecular weight and the mol fraction of the plus-fraction are tuned and the gas-oil ratio is changed to account for density and viscosity variation of the oil.
The live oil viscosity at reservoir pressure and temperature (one of the most important reservoir fluid properties) of the selected North Sea oil reservoirs are shown.



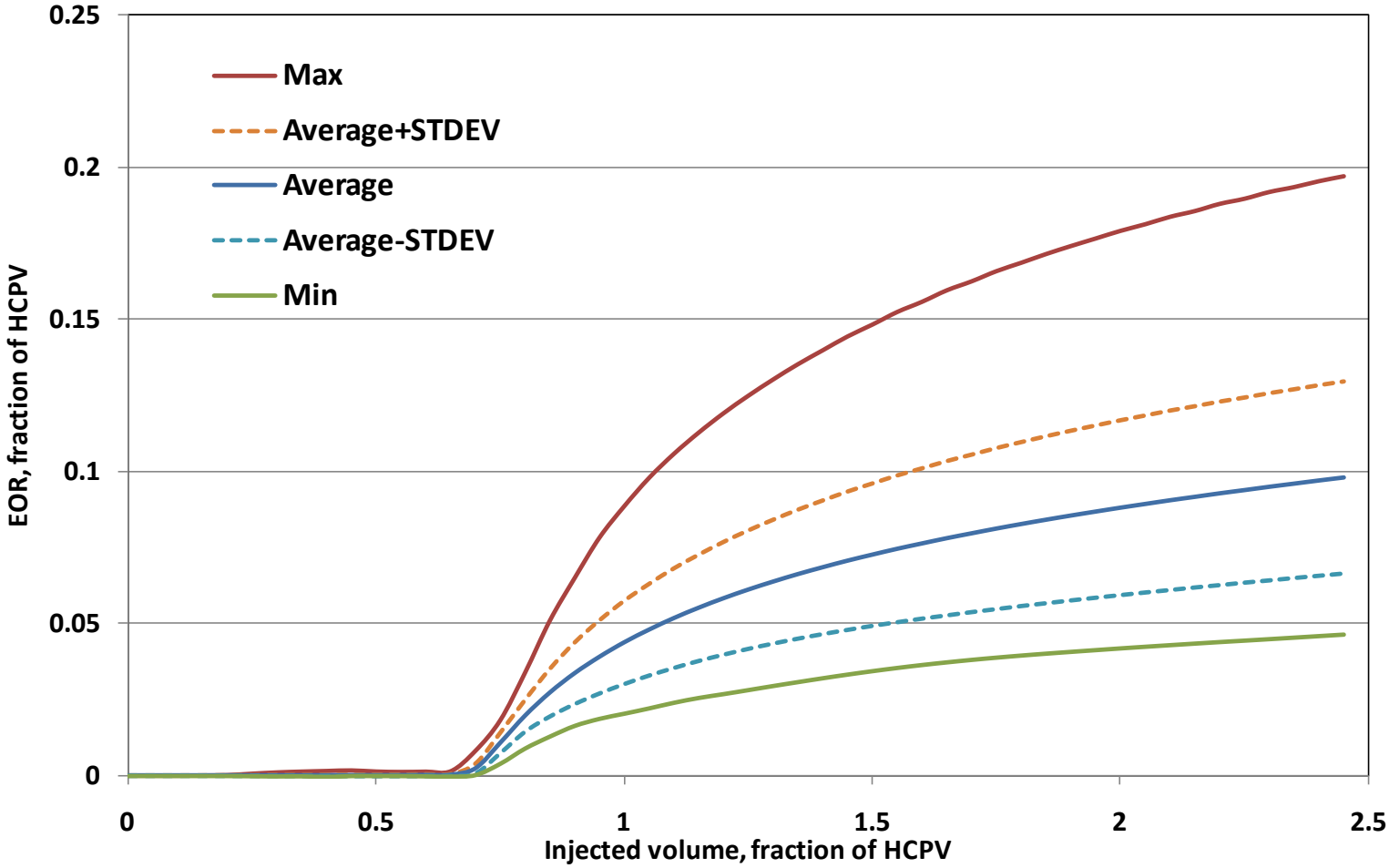
Hysteresis in oil, water and gas relative permeability curves for the North Sea reservoir models



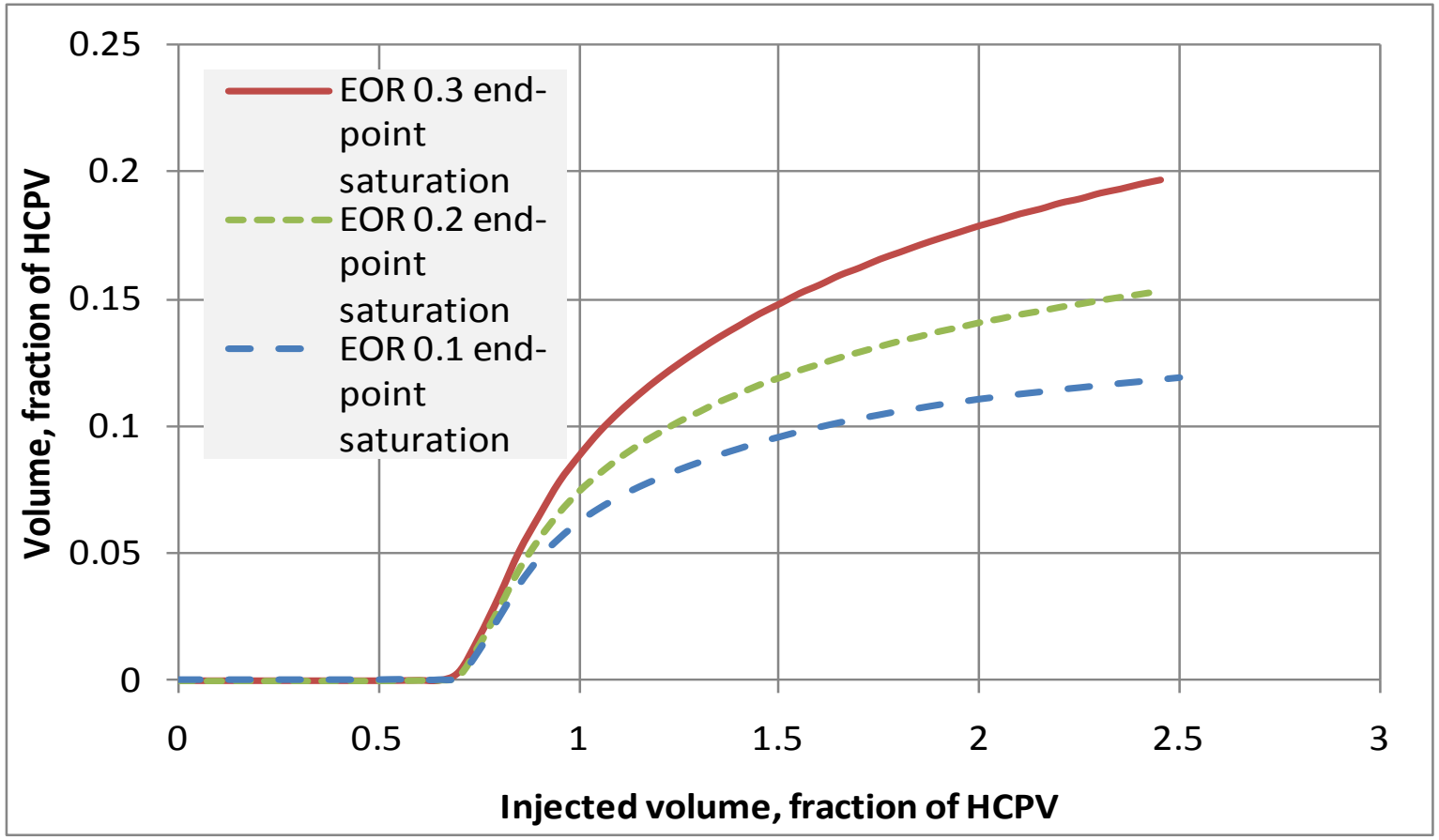
Overview of matrix of parameter type and values in 1134 reservoir simulation cases for each geological deposit

Parameter	Values	Units	# of cases
Model dip	2, 5, 10	degrees	3
Injection rate	300, 600, 1200	Rm^3/day	9
Saturation end point	0.1, 0.2, 0.3		27
k_v/k_h*	0.1, 1.0 (1.0, 10.0)	Fraction	54
Gas-oil ratio	40, 120, 159	Sm^3/Sm^3	162
Onset of CO_2	0.6, 1.2	PV injected	324
WAG cycle length	3, 12	Months	648

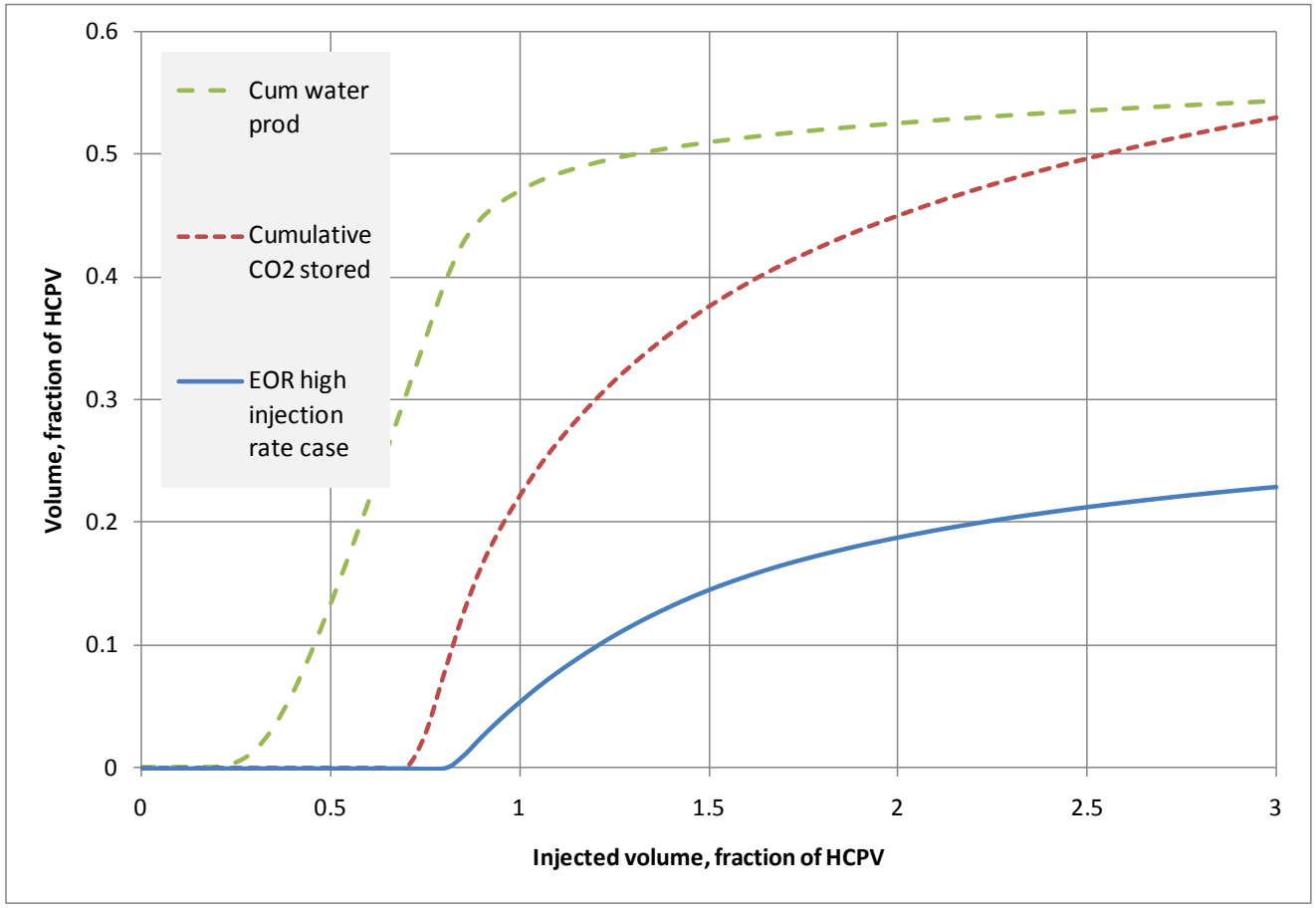
EOR efficiencies by CO_2-WAG injection in North Sea shallow marine deposit model beyond 0.6 HCPV water flooding



EOR efficiency for 0.3, 0.2 and 0.1 oil saturation end-point after water 0.6 HCPV water injection in shallow marine deposit sector model



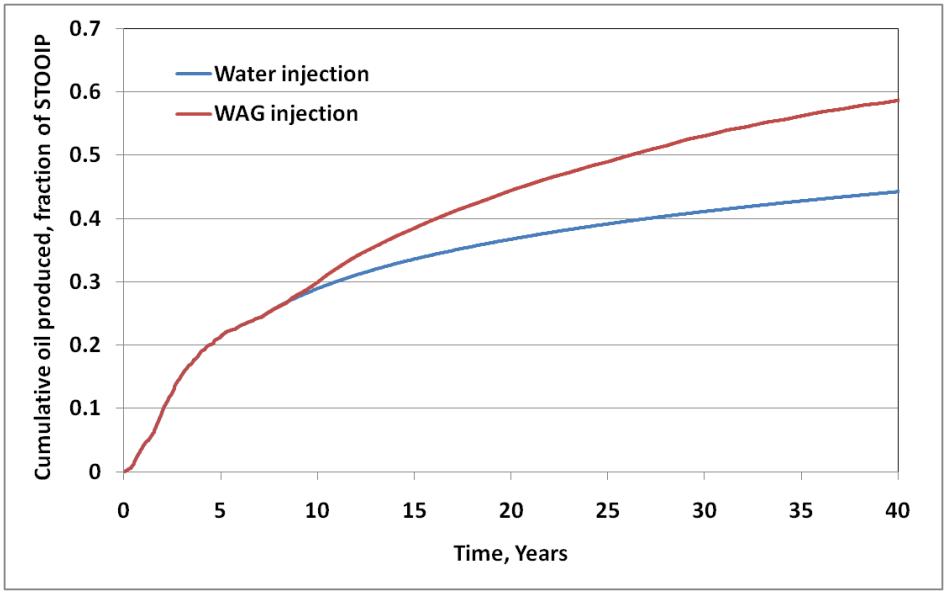
The most EOR efficient CO_2 injection case in North Sea fluvial deposit sector model; EOR, CO_2 storage and cumulative water production



EOR model results compared to a Norwegian water flooded oil field.

- A fault block in shallow marine Brent sandstone with closed boundaries.
- Characteristic parameters for the field model
  - Dip : 13°
  - Rate: 1200-1400 Rm^3/day
  - Saturation end point: 0.05
  - Kv/Kh: ~0.1
  - Oil viscosity (1.2) corresponds to RS less than 40 in the model oil
  - Onset of CO_2: 0.3 HCPV
  - WAC cycle length: 12 months

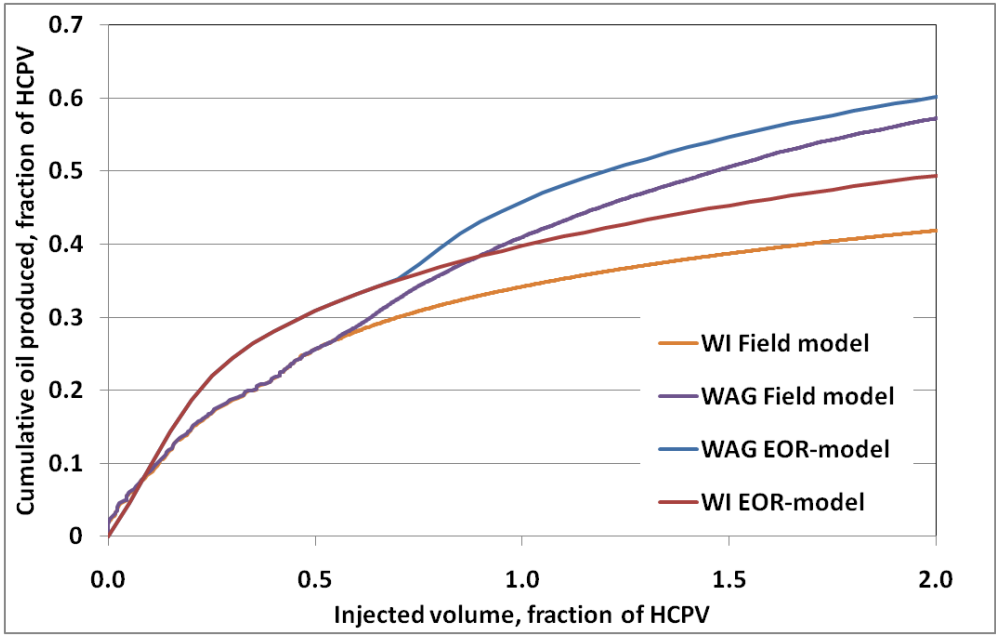
- HCPV 1.36 * 10^7 Rm^3
- Total pore volume 4.14*10^7 Rm^3



Oil recovery on the fault block

Comparing with conceptual model

- Pick results from the model with parameters closest to the field parameters and compare recovery
- Result:
  - Conceptual model gives EOR: 11.5 %
    - 2.5 HCPV injected
  - Field model EOR after 40 years: 14 %
    - Approximately 2.15 HCPV injected
- Further work on scaling from conceptual model to field model is required to enable prediction of CO_2-EOR



Comparison of oil recovery profiles

Conclusions

- Reservoir simulation models of representative North Sea oil reservoirs are constructed to calculate the EOR efficiency of CO_2 injection.
- Substantial difference between the most and the least EOR efficient CO_2 injection and CO_2 WAG injection cases in North Sea oil reservoir models are shown.
- There is a balance between the EOR efficiency and CO_2 storage capacity during CO_2 injection in water flooded North Sea oil reservoir models.

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Thank you for your attention!

Questions and comments are welcome

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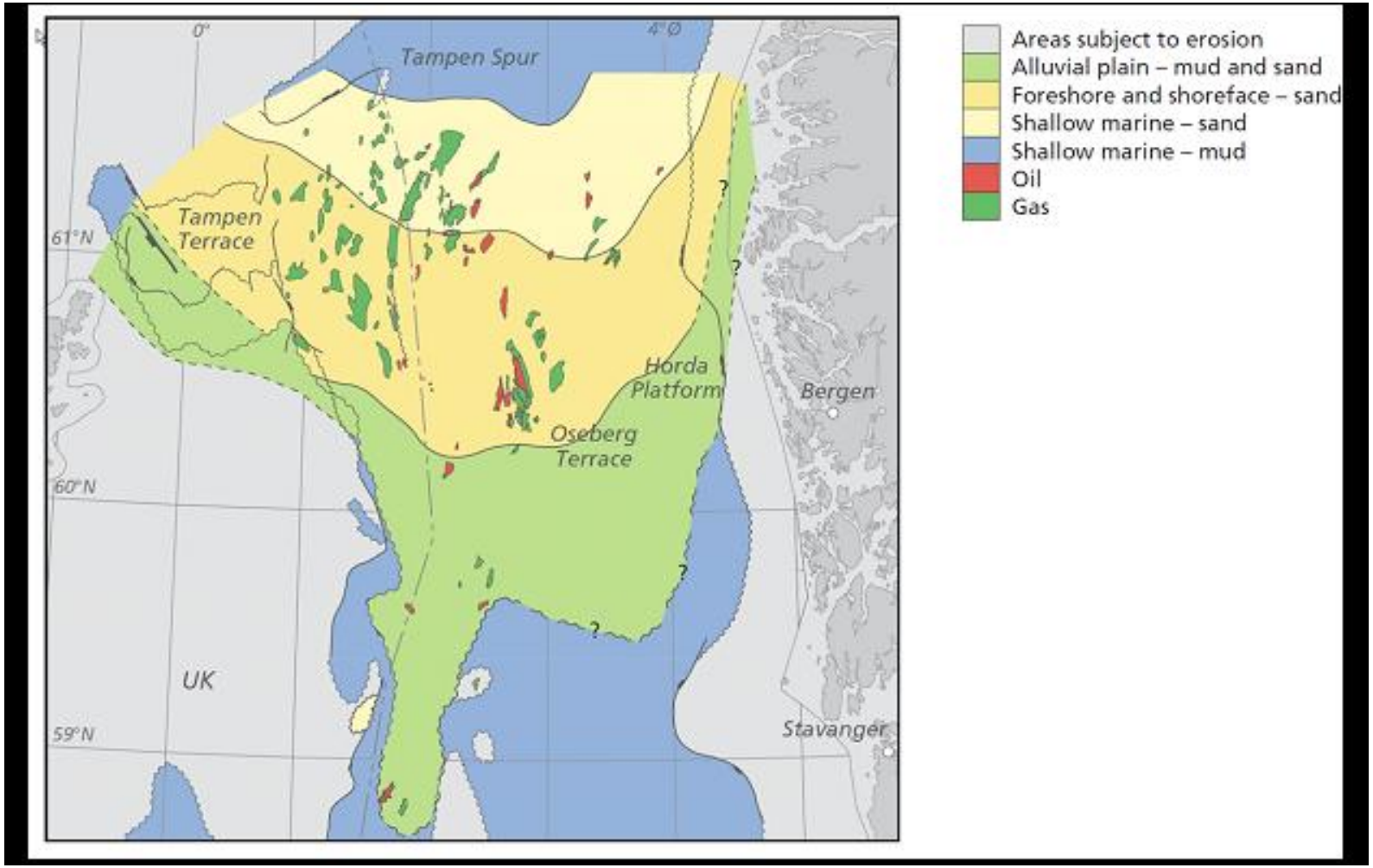
CO2-EOR and storage by CO2 injection in North Sea formations

The Brent delta with marking of the shallow marine and alluvial sandstone oil reservoirs. The Brent Group North Sea area is the most important oil-producing rock type (Jurassic) on the Norwegian shelf.



Different types of river systems developed across the North Sea land during the Late Triassic have quite different reservoir potential