FORCE, Joining Forces Seminar, 22nd and 23rd of May 2013

Exploration Technologies at SINTEF Petroleum Research

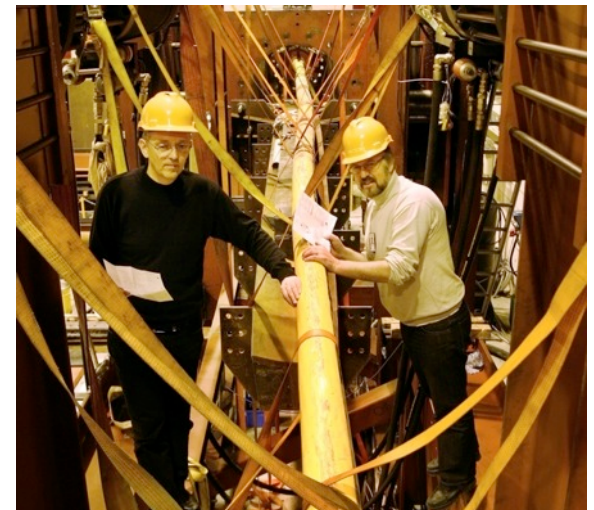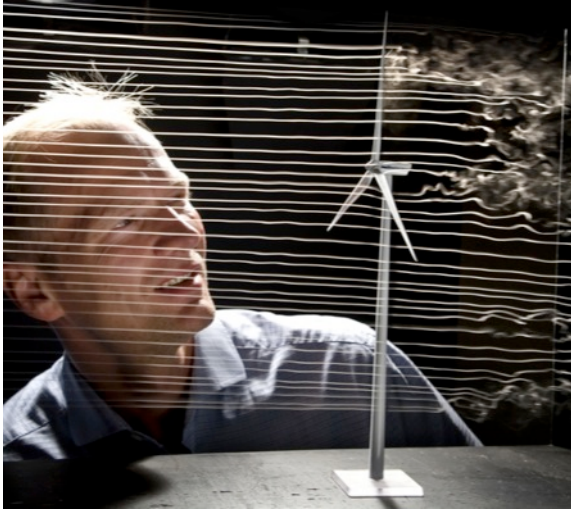Ane Lothe (PhD), Research Director, Basin Modelling Department

SINTEF

is the largest independent research organisation in Scandinavia

- Leading expertise in the natural sciences and technology, environment, health and social science
- 2100 employees from 68 countries
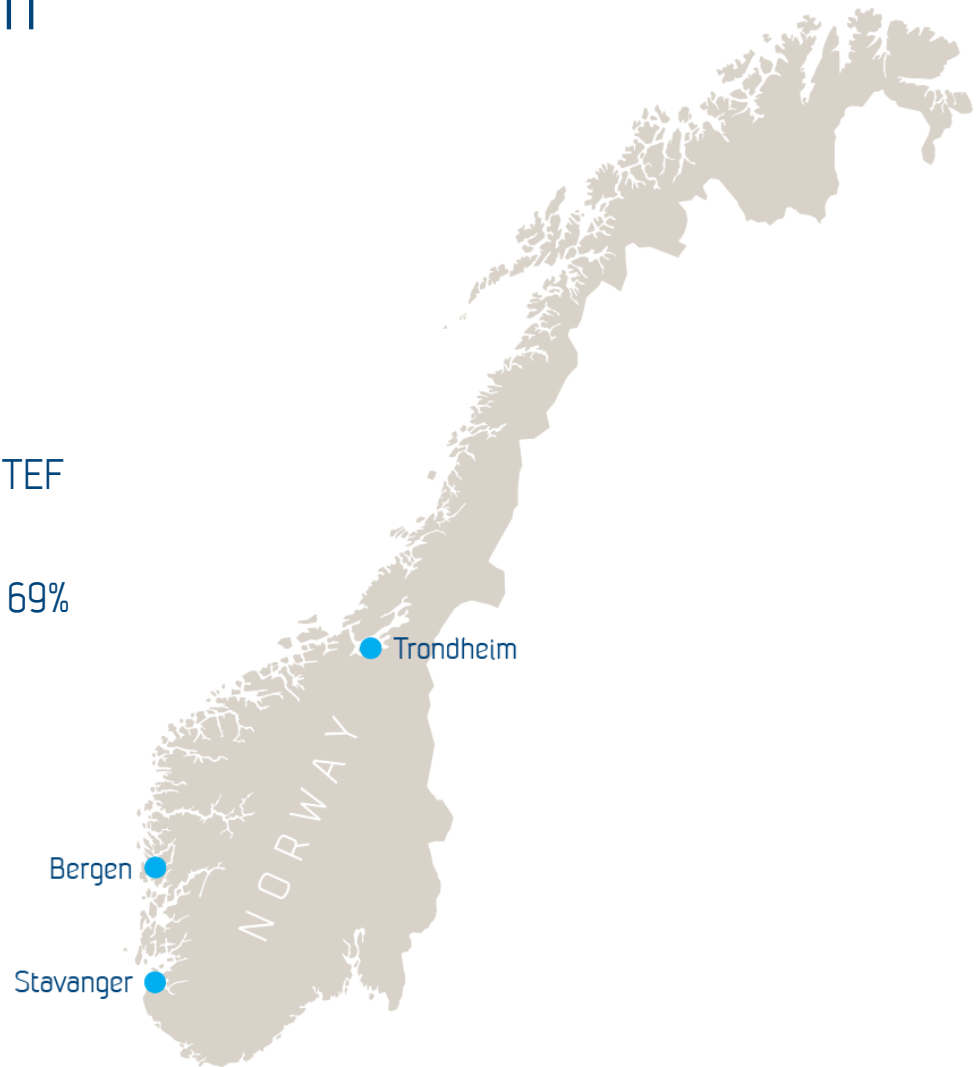- Annual sales of NOK 2.8 billion – customers in 61 countries

SINTEF Petroleum Research

Our vision:

Technology for a better society.

- A non-commercial research subsidiary of SINTEF
- Number of employees: 109
- Proportion of academic staff with doctorates: 69%
- Total number of publications: 141
- Gross turnover: MNOK 199

Facts 2012

Trondheim

Bergen

Stavanger

NORWAY

A multidisciplinary research organisation with international top level expertise in specific fields

Basin Modelling

Drilling and Well

Formation Physics

Geophysics and Reservoir Technology

Wellstream Technology

Basin Modelling Department

Development and application of mathematical models for intra-basinal processes on geological time scales

- Burial history and palaeobathymetry reconstruction

- Source-rock evaluation and facies prediction

- Hydrocarbon generation and multi-component kinetics

- Expulsion/primary migration

- Secondary migration

- Fault and cap rock leakage

- Pressure and temperature modelling
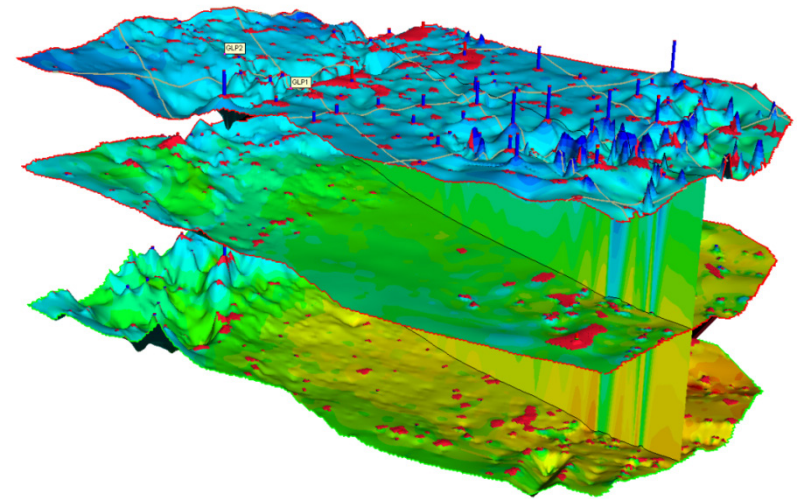
Basin modelling / petroleum systems modelling
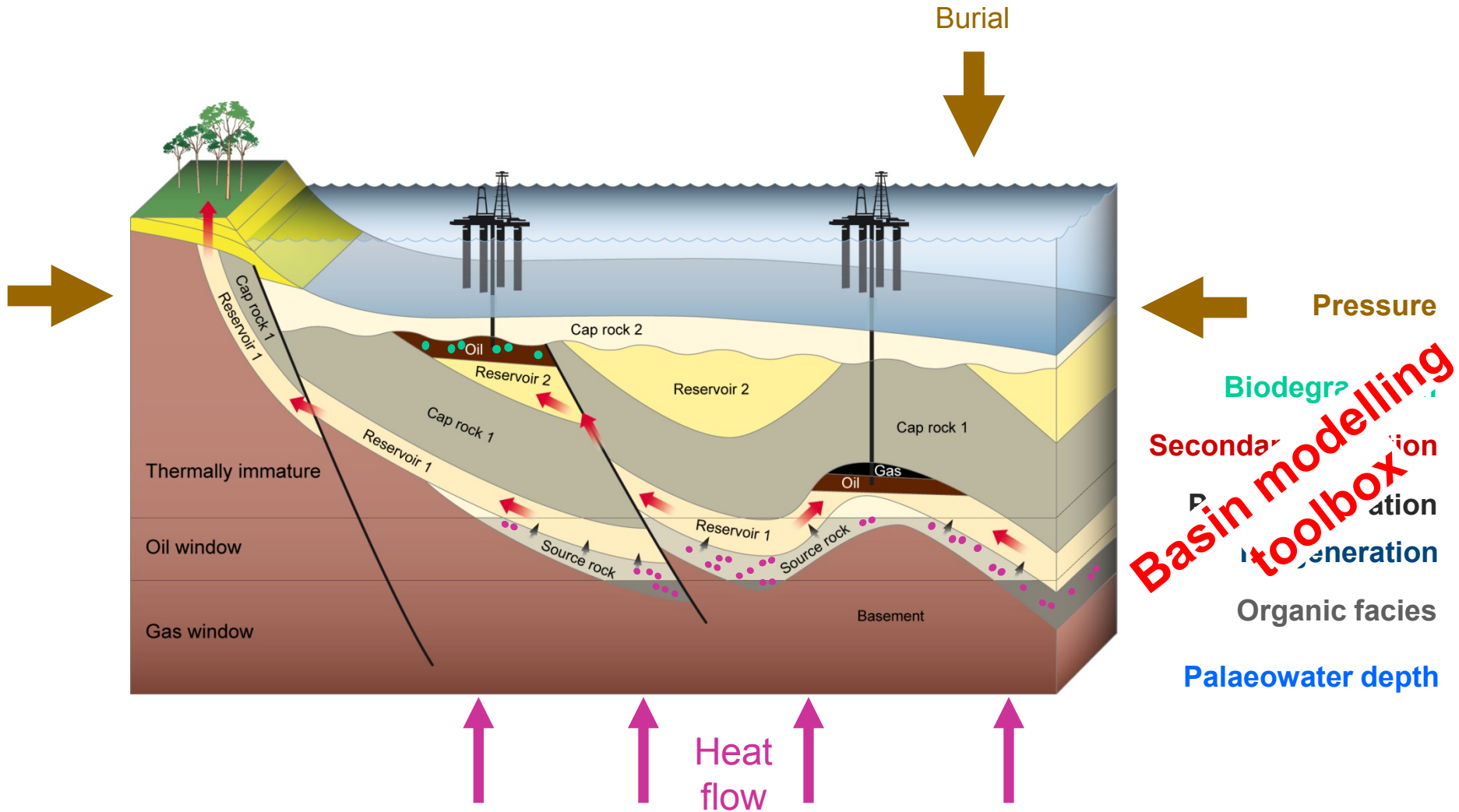
Basin Modelling Software Tools

OF-Mod 1D+3D

predicts organic richness (TOC) and quality (HI) distributions of marine source rocks based on a sedimentation model and process descriptions.

SEMI 2.5D

Geo-model framework, models thermal history, generation – expulsion – secondary migration – accumulation of petroleum using a map-based ray-tracing technique.

SEMI Pressim 3D

simulates pressure generation and dissipation within fault-bounded compartments based on descriptions of various porosity-influencing processes.

Presseis 1D+3D

models temperature history by solving a multi-1D heatflow equation, models 3D pressure distribution based on seismic and rock physics data.
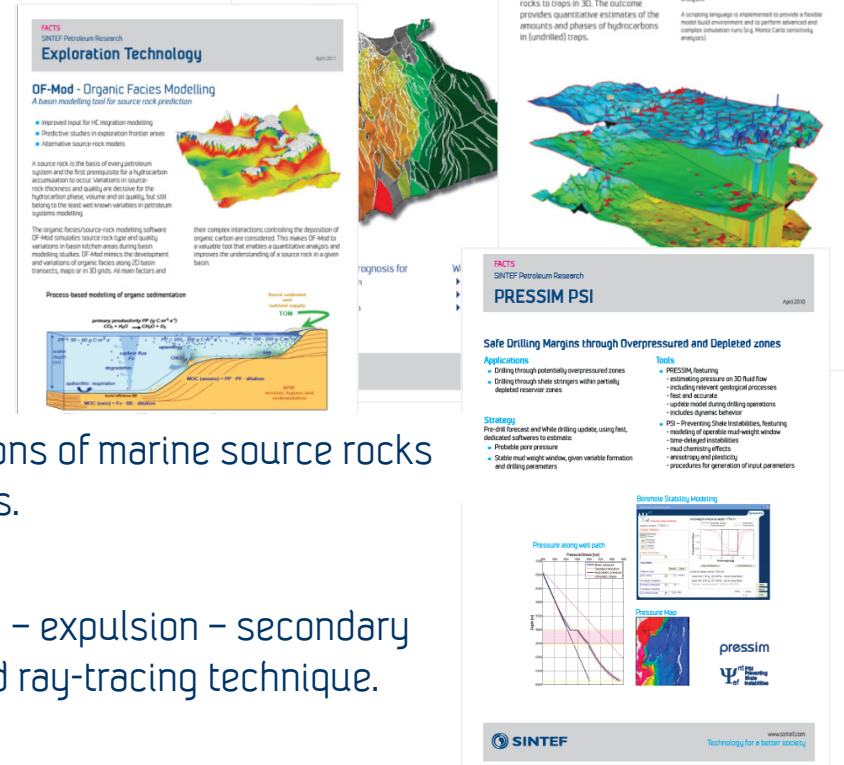
Organic facies modelling with OF-Mod 3D
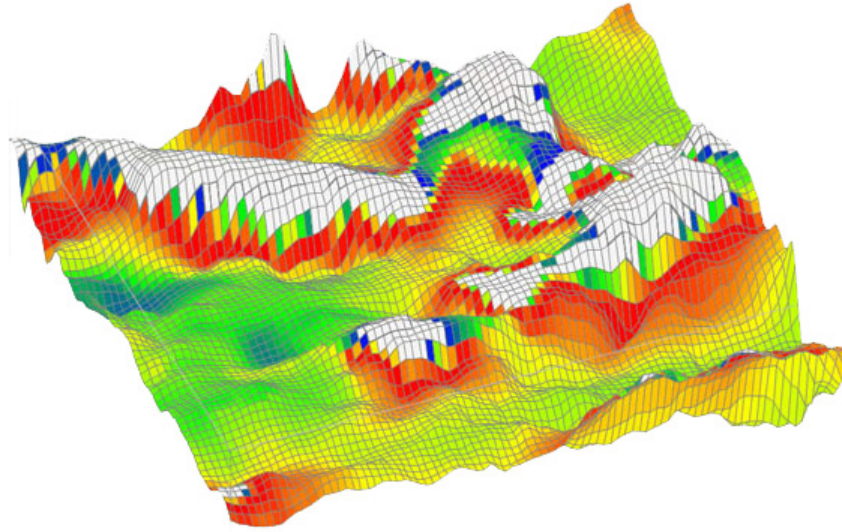
Process-based forward modelling of organic sedimentation allows to predict **pre-burial source-rock potential and –type** away from well control

- Maps generated can be directly imported into the hc migration simulators

SINTEF

OF-Mod 3D case studies provide:

- Calibrated model with analytical data from well samples
- Quantitative prediction of source rock potential and – type away from well control
- Produces 3D grids and thickness maps of different classes SRP
- Produces maps of pre-maturation TOC and HI
- Results can be imported in all secondary migration modelling tools
- Case studies all over the world

Total Organic Carbon (wt.%)

measured
modelled
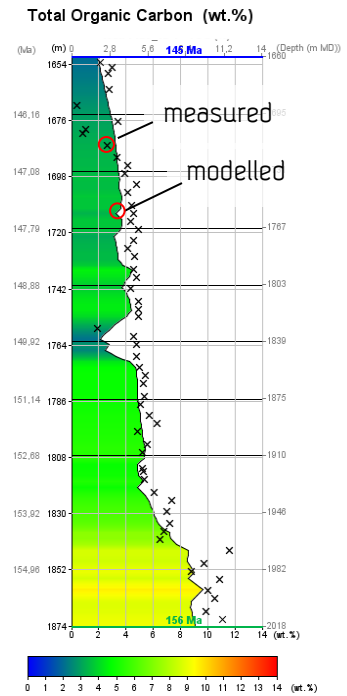
Thickness good SRP (m), period: 156-145 Ma

(m)
150
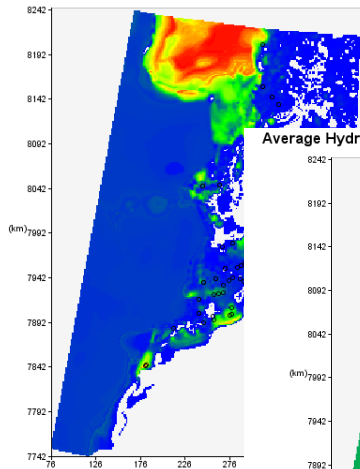
Average Hydrogen Index (mg HC/g C), period: 156-145 Ma

(mg HC/g C
350
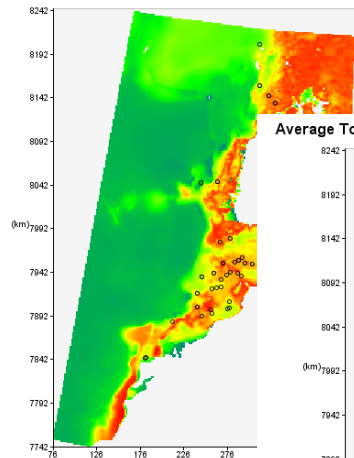
Average Total Organic Carbon (wt.%), period: 156-145 Ma

(wt.%)
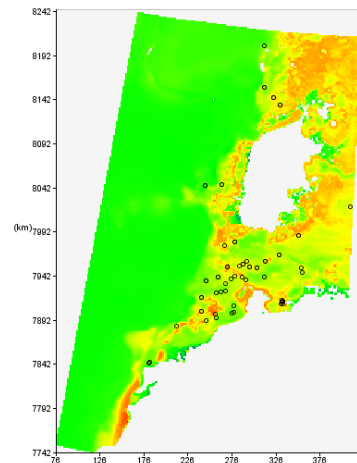
SEMI - Secondary migration modelling
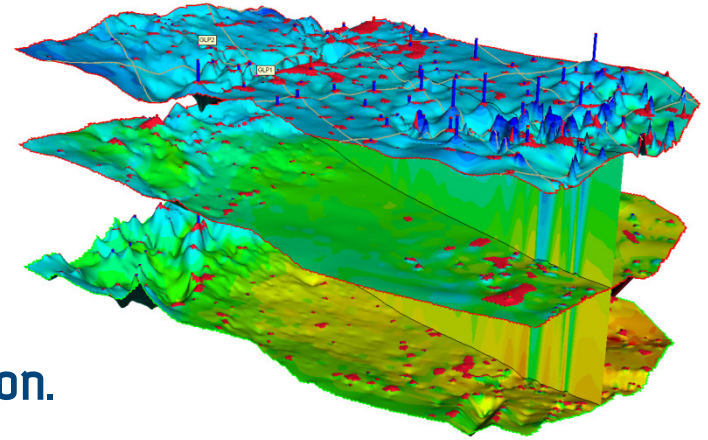
- The secondary migration modelling tool SEMI is our central basin modelling application.

- It uses a ray-tracing scheme and parallel computing techniques to model petroleum migration within stacked carrier rock sequences at high resolution.

- It also handles the processes that cause hydrocarbons to migrate out of traps and provides advanced methods for predicting and accounting for fault seal capacities in migration modelling.

SINTEF

Products – regional integrated studies

preDrill

Simulation and analysis for verification and decision support in well and drilling planning

Pressim
-Pore pressure estimate
PSI
-Prevent shale instability
Flow Model
-Estimation of hydraulics and flow during drilling
Torque & Drag Model
-Estimation of forces during drilling

Pressure/Stress [bar]

Uncertainty is calculated using Monte Carlo technique
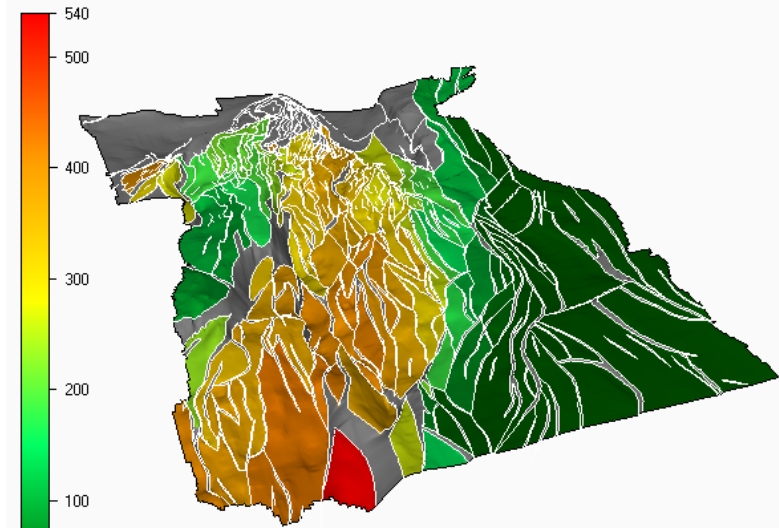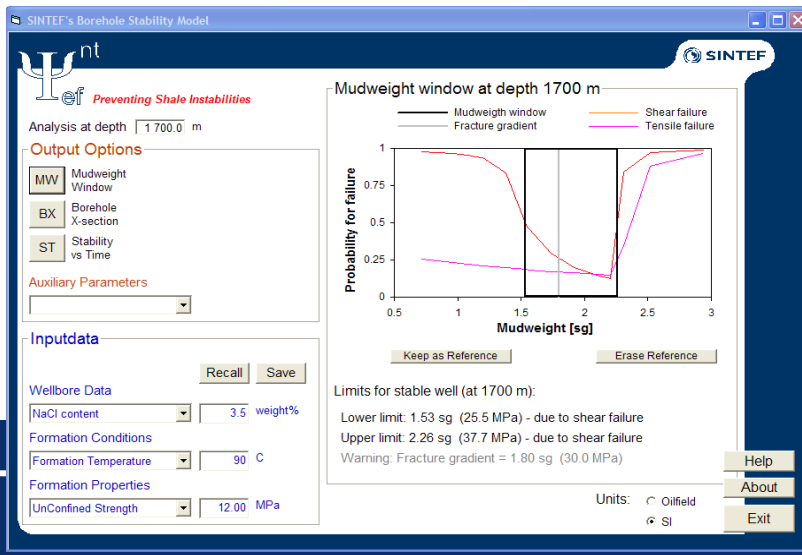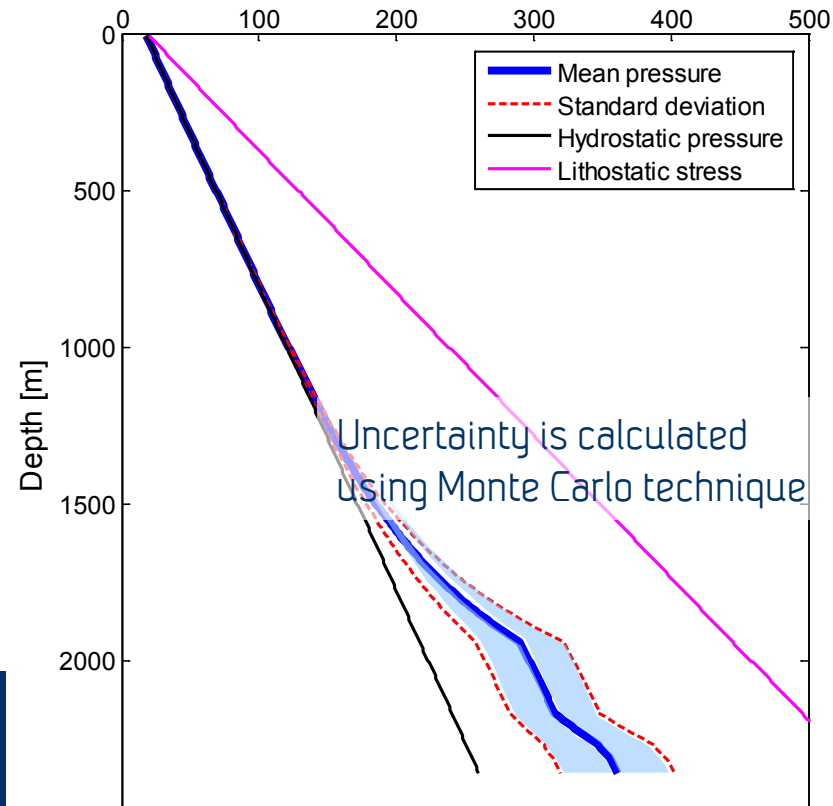
Some selected R&D projects

Impact of Cenozoic structural development and glacial erosion on gas expansion, hydraulic fracturing and leakage

- Start 2013 to 2016
- ENI
- One PhD student
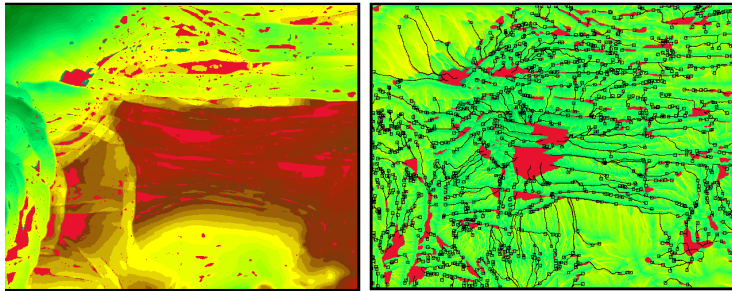
Oil and gas pools   Active spill points

(Figures from another study)

BASE -Deep Weathering –JIP
Start late 2013 together with NGU

Migration and risk modelling for CO_2 storage

www.sitechar-co2.eu

OF-Mod 3D Facies - JIP
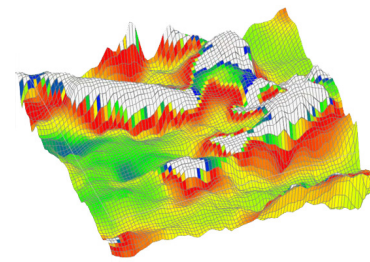
Modelling linked sedimentary and organic facies for the prediction of source rock deposition

- Geologically-informed lithology model, improved stratigraphy model,
- Modelled constraints by input data
- Uncertainty analysis of the organic deposit simulation results

- Easily extendable for future use
  (different depositional environments, different types of uncertainty, …)
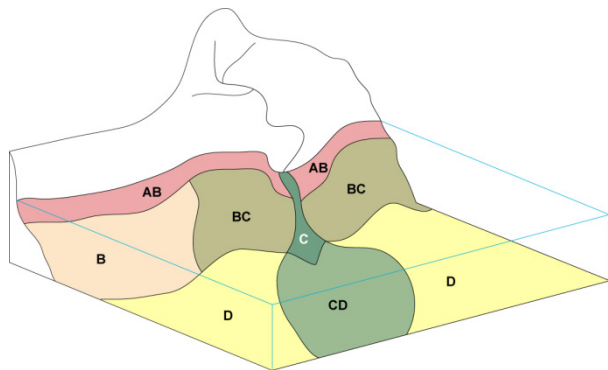
Project duration 3 years, 2010 -2013
4 participants

OF-Mod 3D Facies - JIP

Modelling linked sedimenta~~~~s
for the prediction of sou~~~~

- Geologically-informed lith~~~~ ~graphy model,
- Modelled constraints ~~~~
- Uncertainty analys~~~~ ~ulation results

- Easily exter~~~~
  (different~~~~ , different types of uncertainty, …)

Project duration 3 years, 2010 -2013
4 participants

New phase – Carbonates

- Include carbonate mud environments
- This is where highest organic carbon concentrations are found

Project proposal : **Uncertainty in 3D palaeobathymetry reconstruction**

- Uncertainty to be determined for
  - seicmic depth interpretation that will influence decompaction
  - lithology variations
  - lithospheric stretching
  - restoration of erosion
- Not a full tectonic reconstruction

Deliverables

- Quantifying the uncertainties in 3D
- Better geomodels that can be used as input into
  - source rock modelling
  - migration modelling
  - sedimentation modelling

Initial data

Flatten top of infilling unit and decompact

Result on the timestep under study

Define surface which intersects emerged areas

Final result after intersecting surface has been subtracted
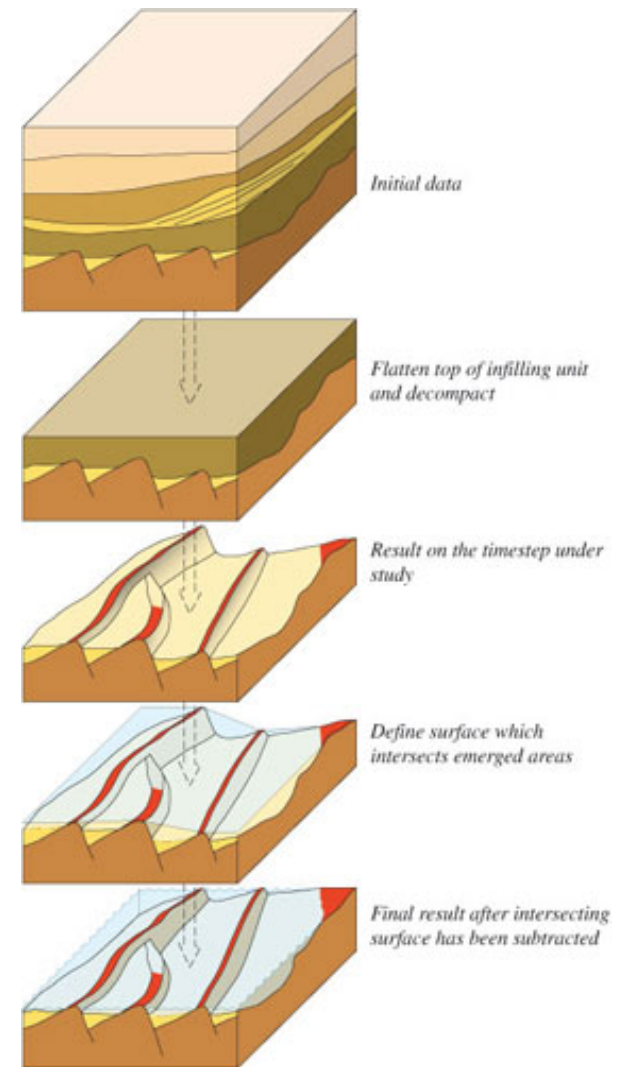
The effect of sill intrusions on the Petroleum system

- On-going JIP project with Tectonor and Royal Holloway University

- Motivation:

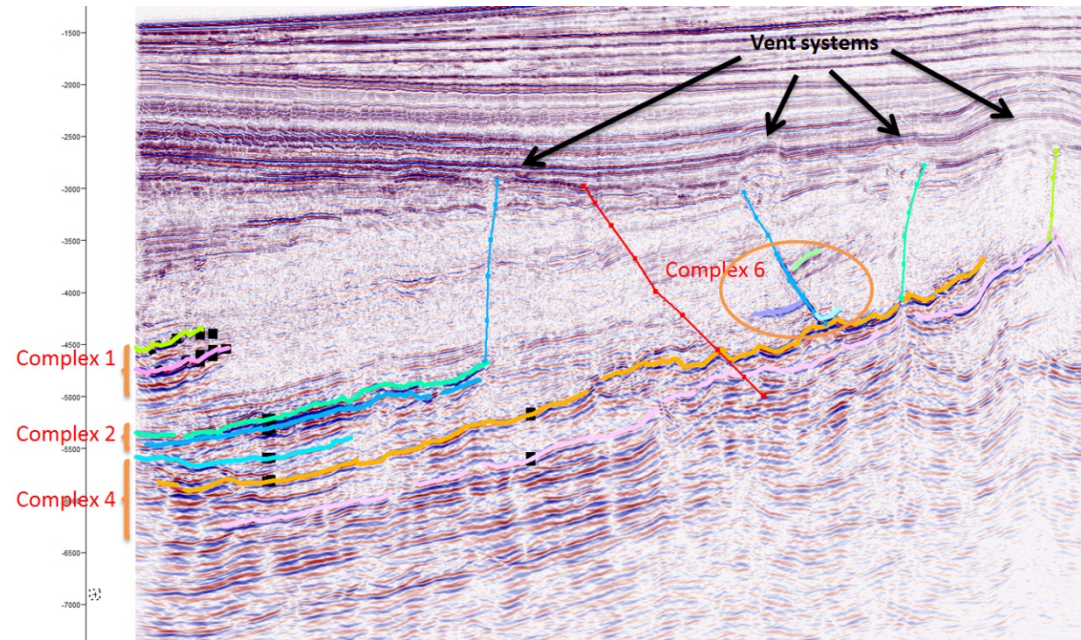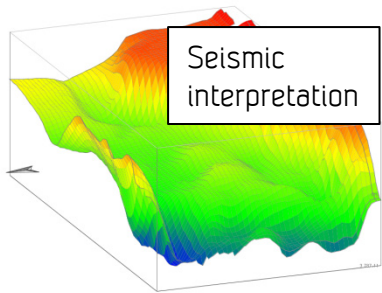 - Thermal effects of the sill emplacement on maturation of hydrocarbons

  - Identify under which circumstances a sill may act as a reservoir and/or as a top seal
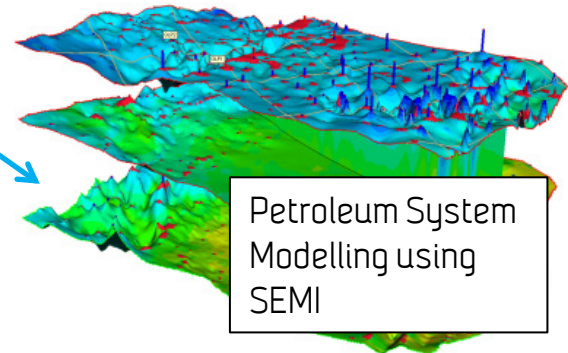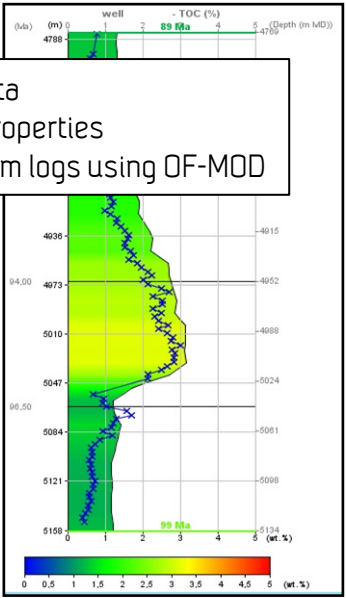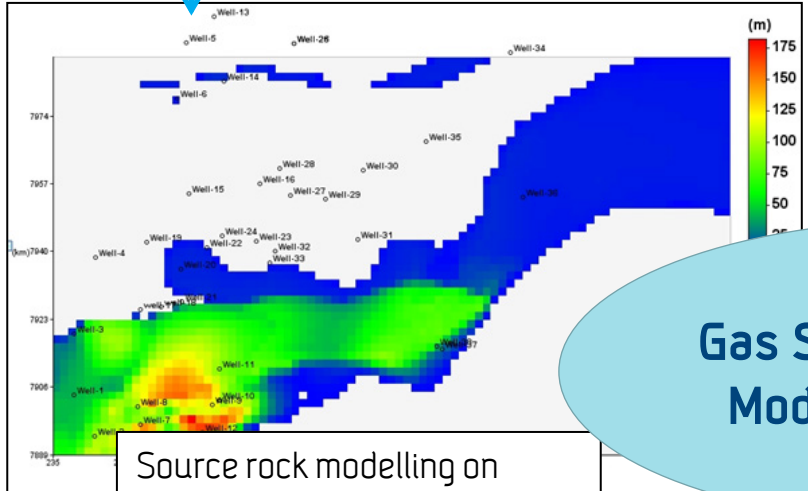

New software development phase:

- Integrating hydrocarbon migration and entrapment within the sill intrusions

Seismic interpretation

Well data
Rock properties
TOC from logs using OF-MOD

Petroleum System Modelling using SEMI

Natural fracturing and pressure modeling in shale gas: reconstruction of geopressure using SEMI-Pressim
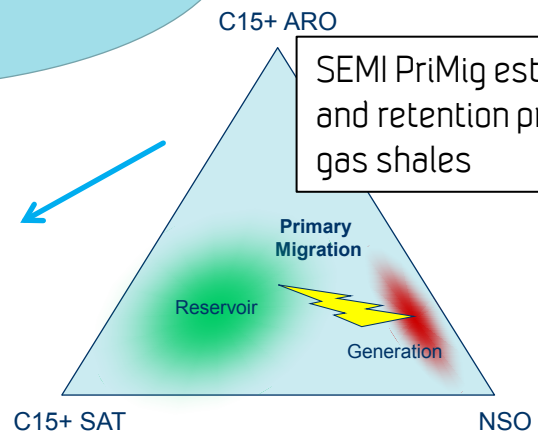
Gas Shale Exploration Modelling Workflow

Source rock modelling on basin scale using OF-MOD, output maps:
- Total organic carbon (TOC)
- Hydrogen index (HI)
- Accu. thickness (m) of organic facies classes

Sensitivity and risk Analysis

SEMI PriMig estimate expulsion and retention processes of HC in gas shales
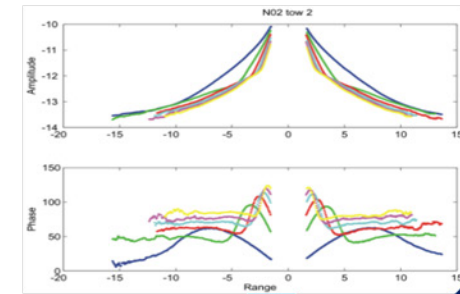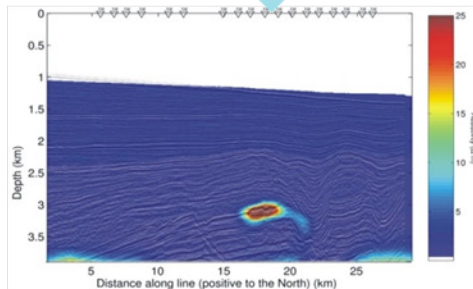
C15+ ARO

Primary Migration

Reservoir

Generation

C15+ SAT

NSO

Thank you!

More information:

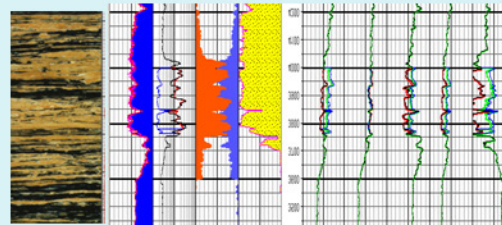www.sintef.no/petroleum

or

ane.lothe@sintef.no

JoiSE

CSEM inversion

Rock physics driven integration
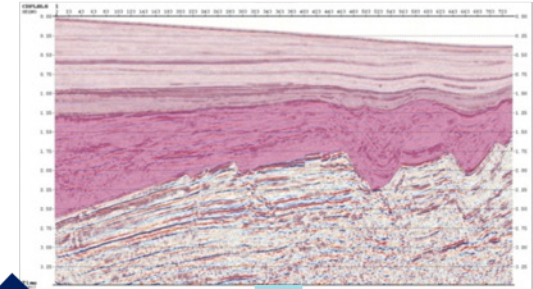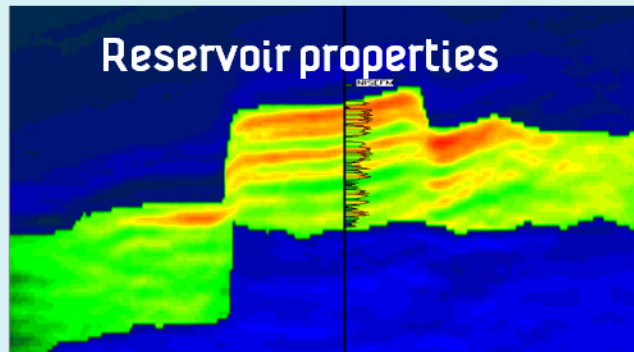
Core and Well data

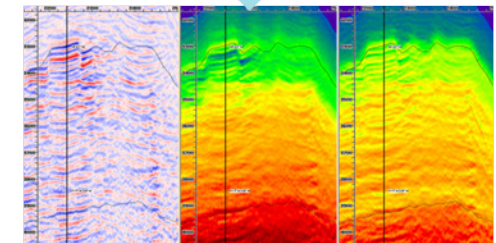Rock Physics properties, hydrocarbon volumes, phases, *uncertainties*

Cross-calibration

Basin modelling: hydrocarbon volumes, phases, *uncertainties*

Reservoir properties

Seismic inversion

Close collaboration from Seismic, FP and BM departments.

Provide oil and gas industry not only higher resolution geophysical structural models but also the important reservoir information what the model means in terms of hydrocarbons.