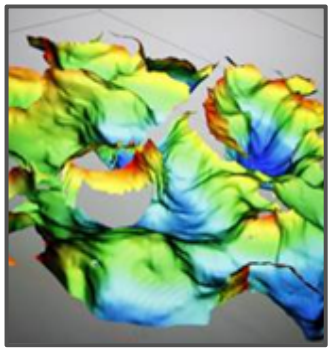
Future Trends in Reservoir Management

Dominique Marion, TOTAL



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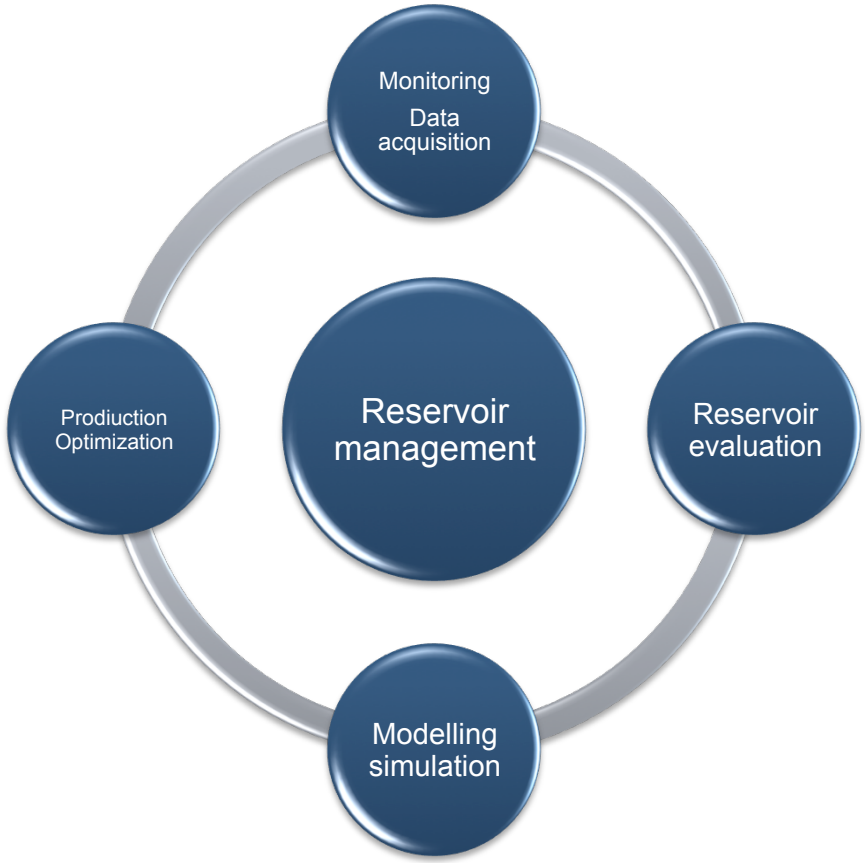
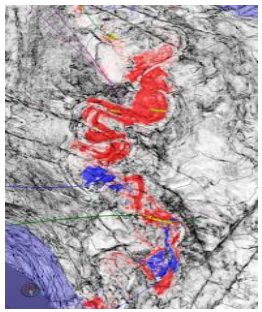
Reservoir Management

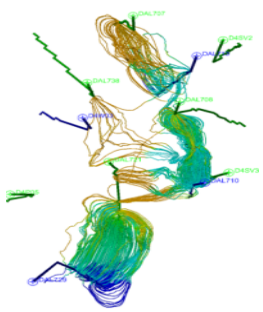
Maximize *economic value* of hydrocarbon fields with implementation of cost effective *production optimization* techniques and *recovery mecanisms*

⇒**Comprehensive analysis of *reservoir behavior* and *production mecanisms* throughout the life cycle of a field**

⇒**Accurate *model representation* of the reservoir – wells – facilities system**



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Field monitoring and data acquisition

Real Time – Permanent - Redundancy

The Field Monitoring leading principles

Enhanced data acquisition

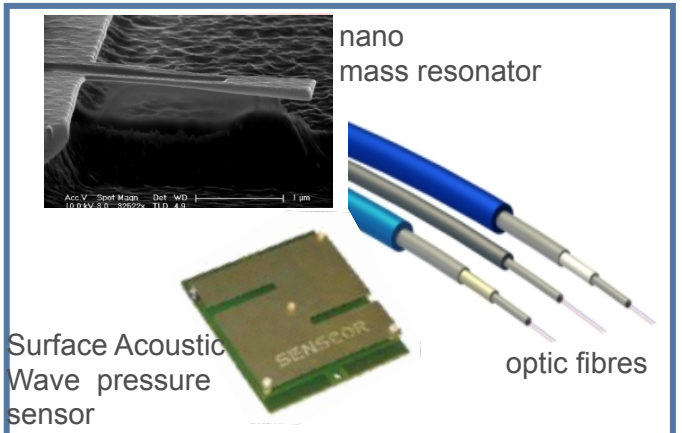
- Intelligent Sensors
- Distributed Measurements (Fiber Optics)
- Micro & nano-sensors (MEMS/NEMS)
- Wireless sensors (active / passive)

Real-time information

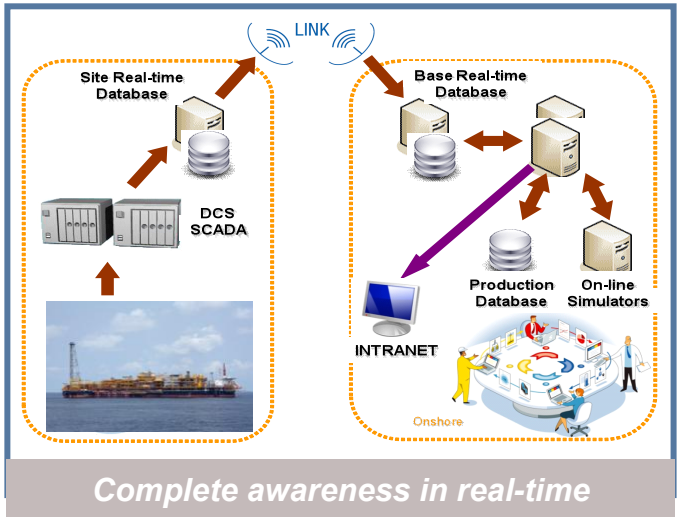
- Permanent monitoring systems
- State-of-the-art communication Network
- Exception-based surveillance
- On-line modelling

Integrated Operations

- Across assets (‘full awareness’)
- Across distances (remote support)
- Across disciplines (collaborative work)



Emerging sensor technologies



Complete awareness in real-time

The right information to the right people in the right place, at the right time

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Advances in data acquisition

Develop permanent monitoring solutions

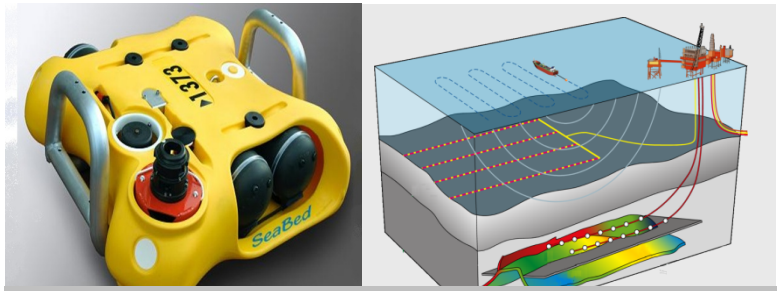
- Downhole permanent sensors
- Permanent / semi-permanent seismic arrays
- Subsea sensors

Improve spatial coverage

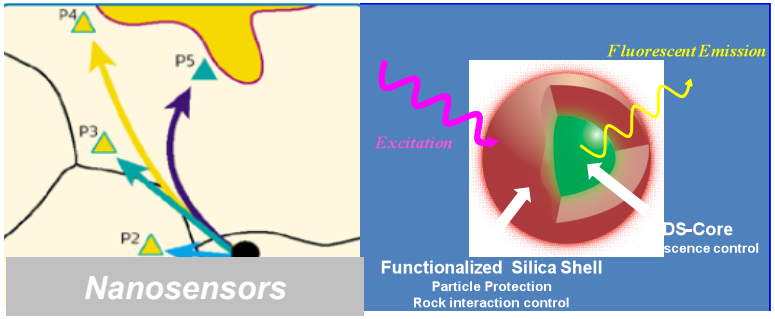
- Distributed fiber optics
- Remote sensing (camera / airborne / satellite)
- Deep reservoir investigation
  (tracers, potential methods, µ-seismics)

Reduce instrumentation costs

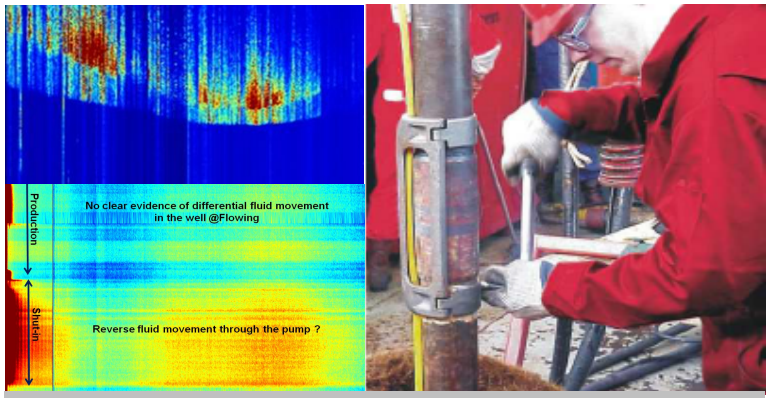
- Low cost sensors (Nano-sensors)
- Wireless networks



Subsea seismic nodes (Dalia field, Angola)



Nanosensors



Fiber optics sensing (Sendji field, Congo)

monitoring the entire reservoir – well – facilities system

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Advances in integration & optimization

Monitor actual vs. expected performance

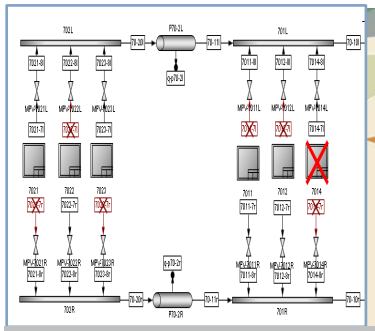
- Automated Key performance indicator reporting
- On-line simulation
- Use data redundancy for cross-validation

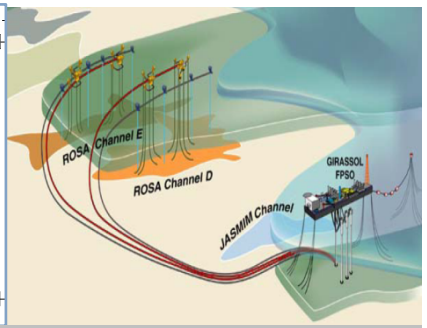
Remove distance or discipline barriers

- Virtual exchanges (data centers, videoconference)
- Physical environments (collaborative centers)

Achieve continuous optimization

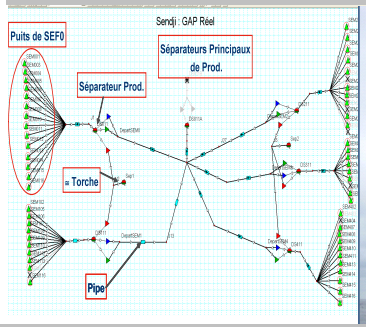
- Model-based optimization
- Advanced process control





Virtual metering (Rosa field, Angola)

Total Activity Support Center (Norway)



Online gas-lift optimization (Sendji field, Congo)

Measuring the performance of the entire reservoir-well(facilities system

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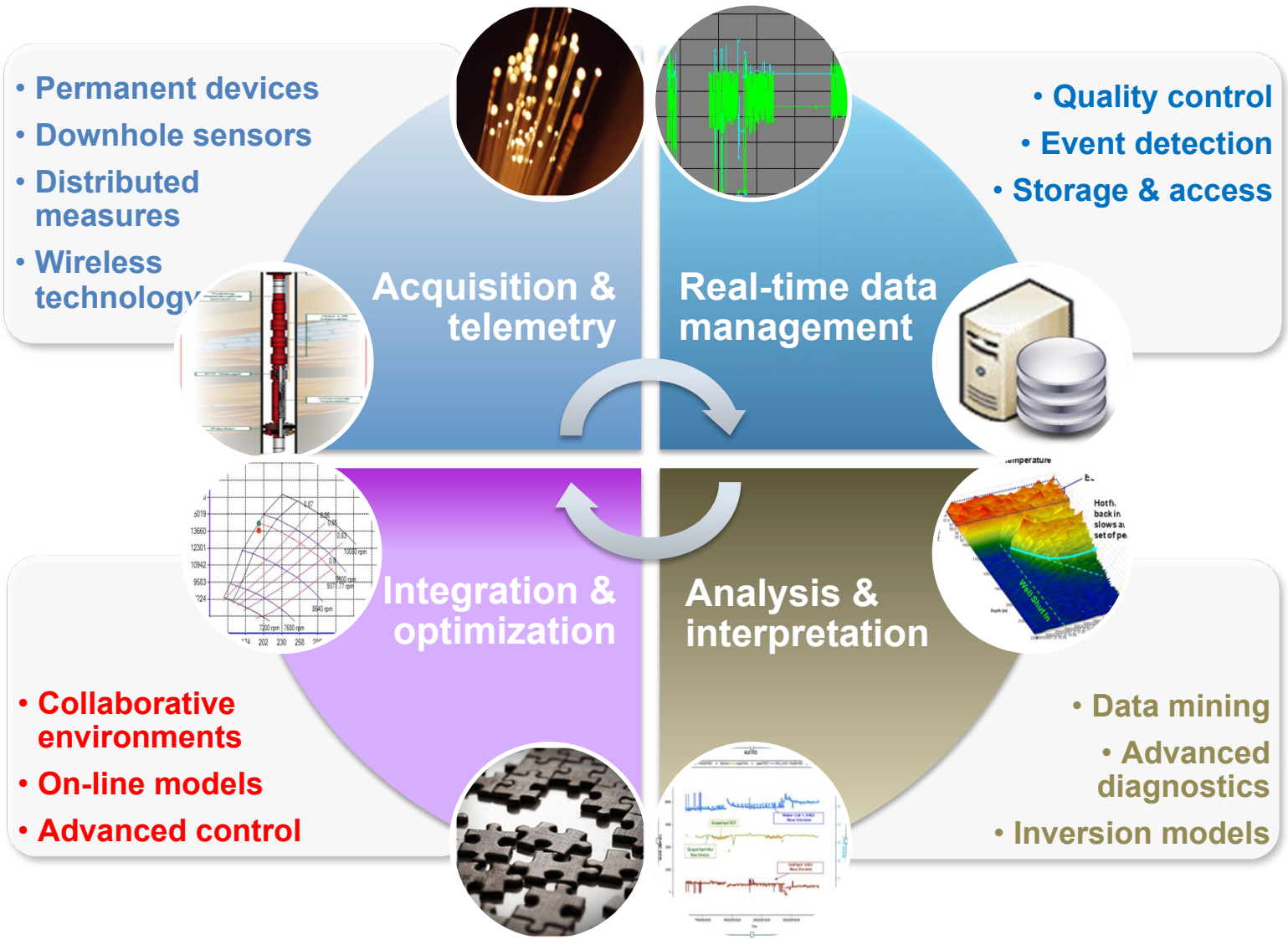
Technical challenges



Mastering the chain from raw data to decision making

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Reservoir Evaluation

Seeing is Believing

Challenges in Reservoir evaluation

Increasing diversity of problematics

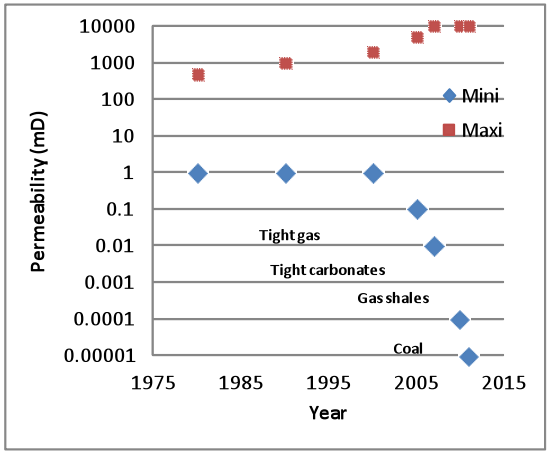
- Permeability from 0.0001 mD to 10000 mD
- Porosity from 1% to 40%
- Fluid viscosity from 0,2cP to 10^6 cP

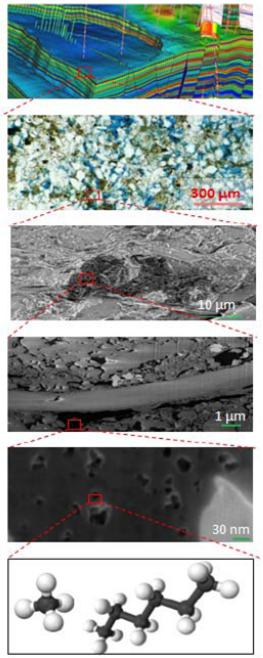
Evolution of recovery mechanisms

- « Smart water »
- Chemical
- Thermal in situ / ex situ…

Physics of fluid flow in porous media to be revisited…

.. But what is the correct scale of investigation?





Megascale 2.5 mm - km	Darcy Flow
Macroscale 0.1 -2.5 mm	Darcy Flow
Mesoscale 7.5 - 100 µm	Darcy flow
Microscale 0.1 -7.5 µm	Darcy flow
Nanoscale 7.5 -100 nm	Capillary condensation and adsorption; Diffusion
Molecule scale 3 - 5 Å	Competing intermolecular interaction and molecule – surface interaction

TOTAL

Pore scale imaging using X-Ray microtomography

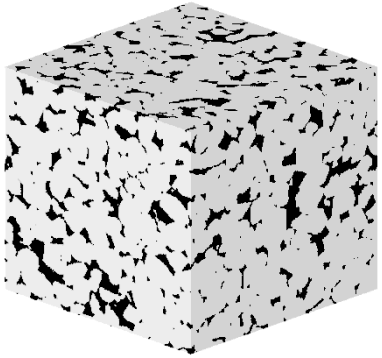
Investigate multi phase flow at pore for complex recovery mecanisms

Current application domain

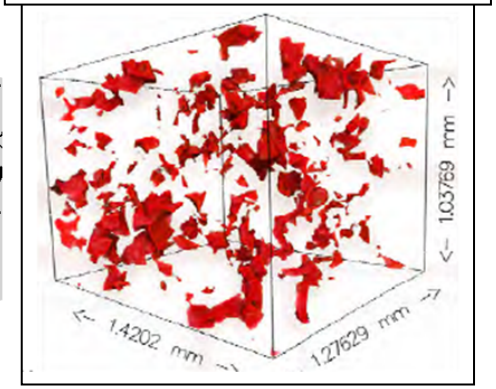
- Sandstone, K > 50 mD
- Access to residual immiscible fluids only

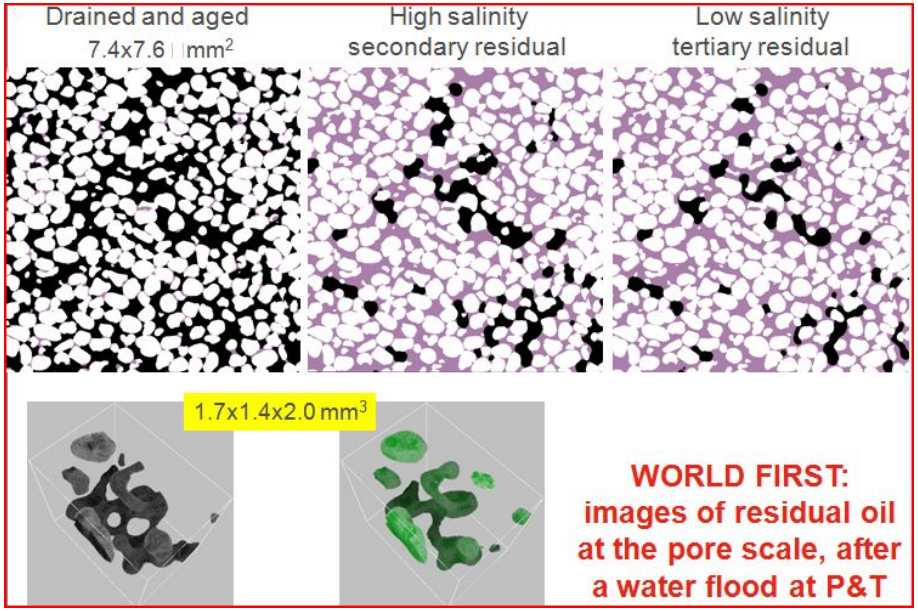
Tomorrow

- tighter and heterogeneous rocks, visualize flowing fluids



µCT image of residual fluids





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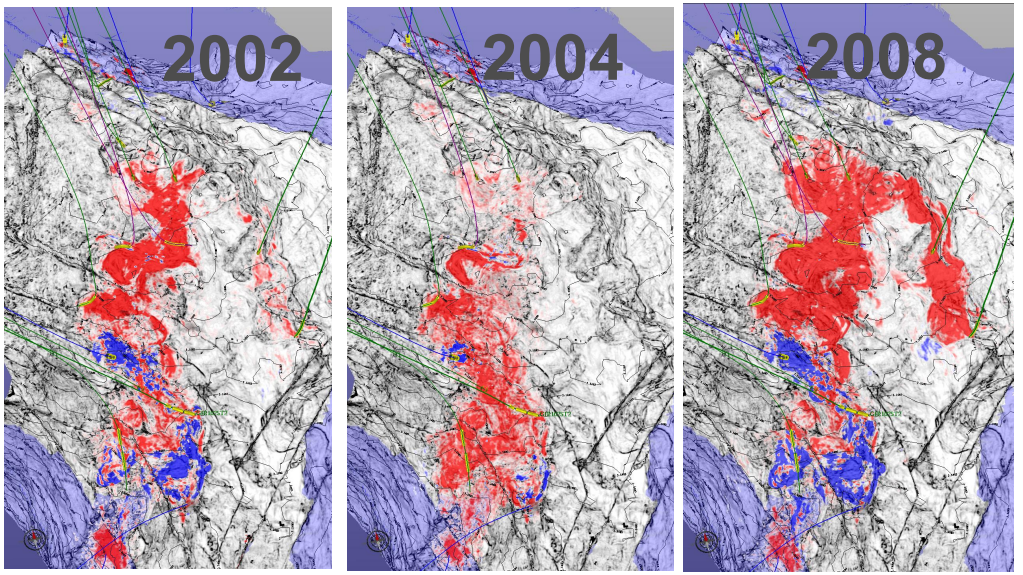
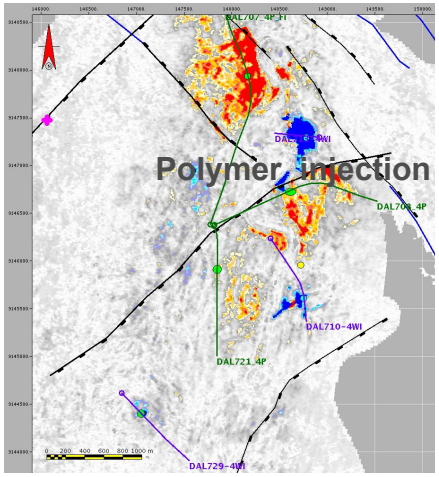
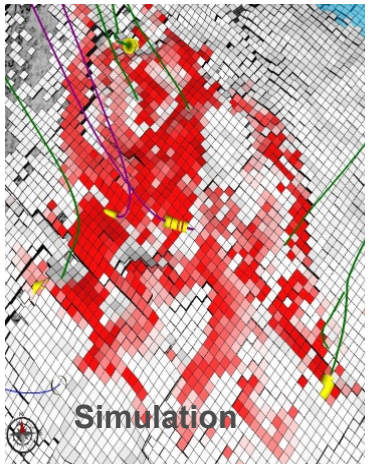
Visualisation of production mecanisms at seismic scale

- water injection and gas injection **pathways in 3D**
- Identification of ***undrained*** ***area*** to locate infill wells
- **History match** of simulation model to ***improve production forecast***
- Measure of efficency of ***recovery mecanisms*** (polymer flood







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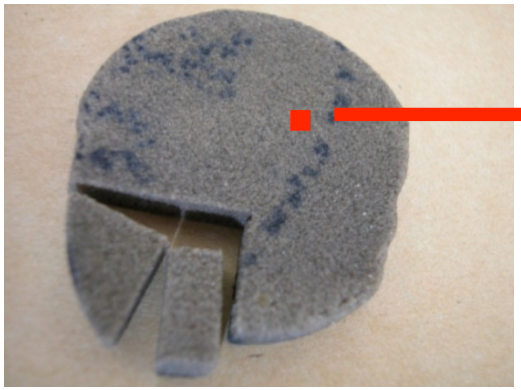
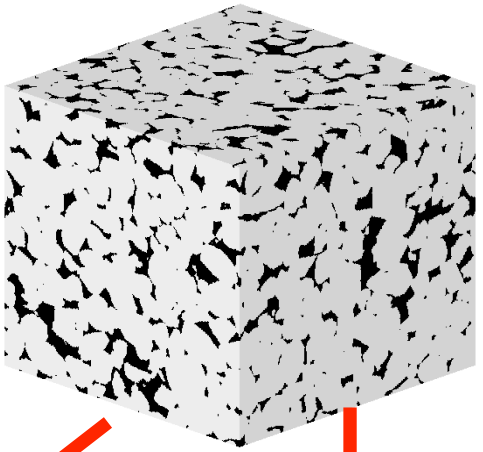
Reservoir modelling and simulation
The right scale with HPC

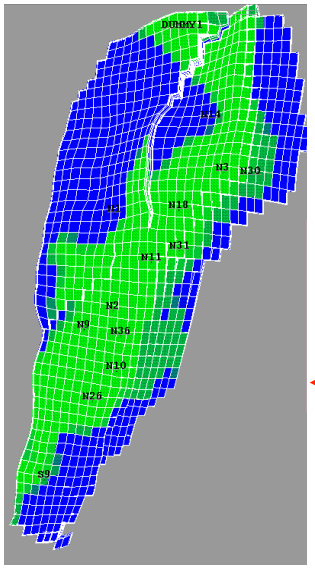
Modelling pore network to simulate complex flow paterns



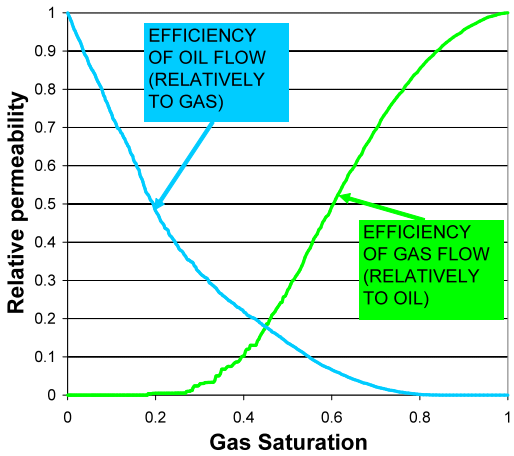
Core sample

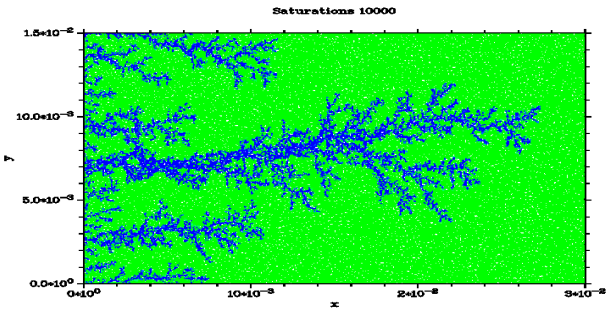


Digital Pore Scale Model



Application in reservoir model





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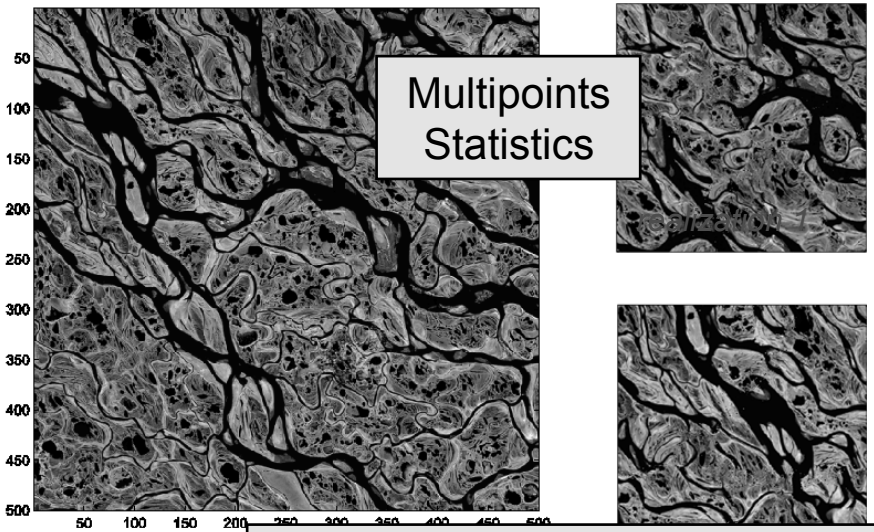
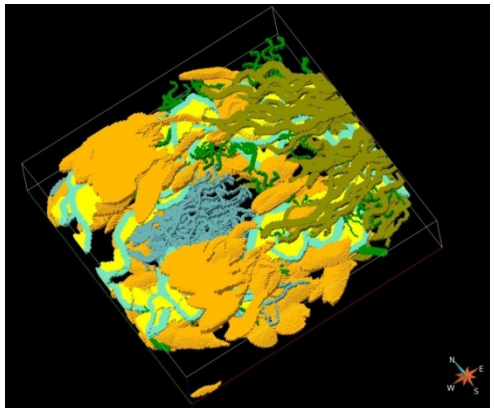
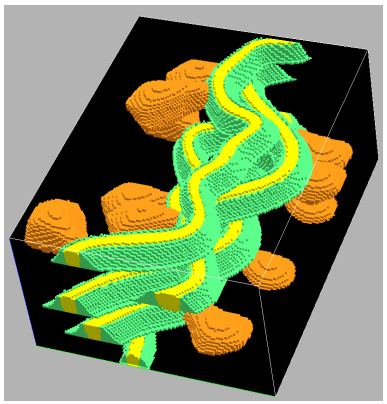
Modelling geological features and processes to capture reservoir heterogeneities

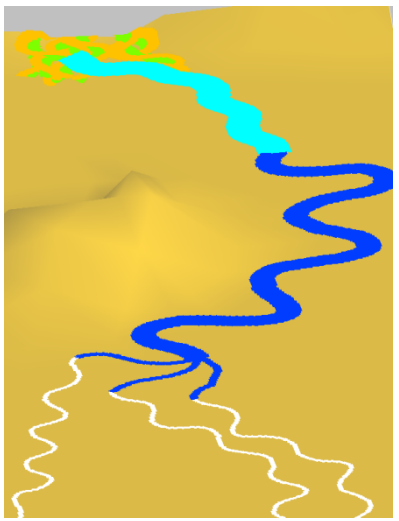


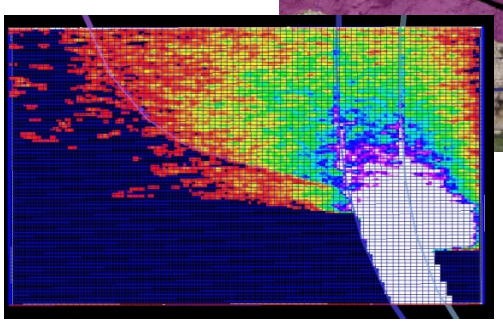
Multipoints Statistics

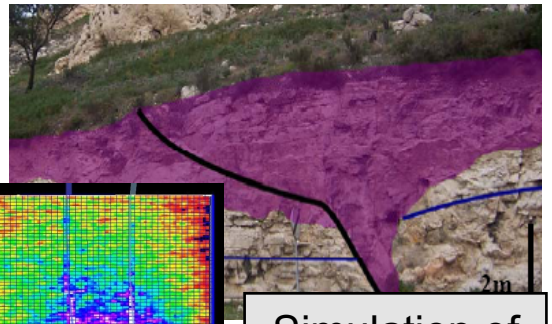
Simulation of sedimentary processes



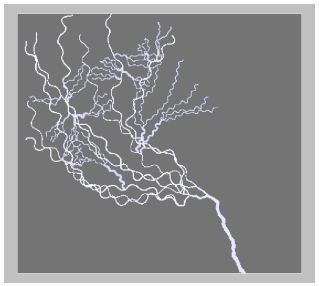


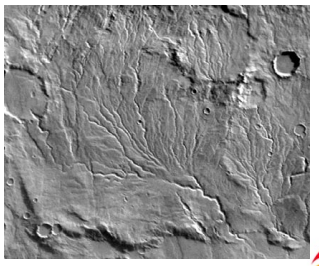






Simulation of diagenetic processes





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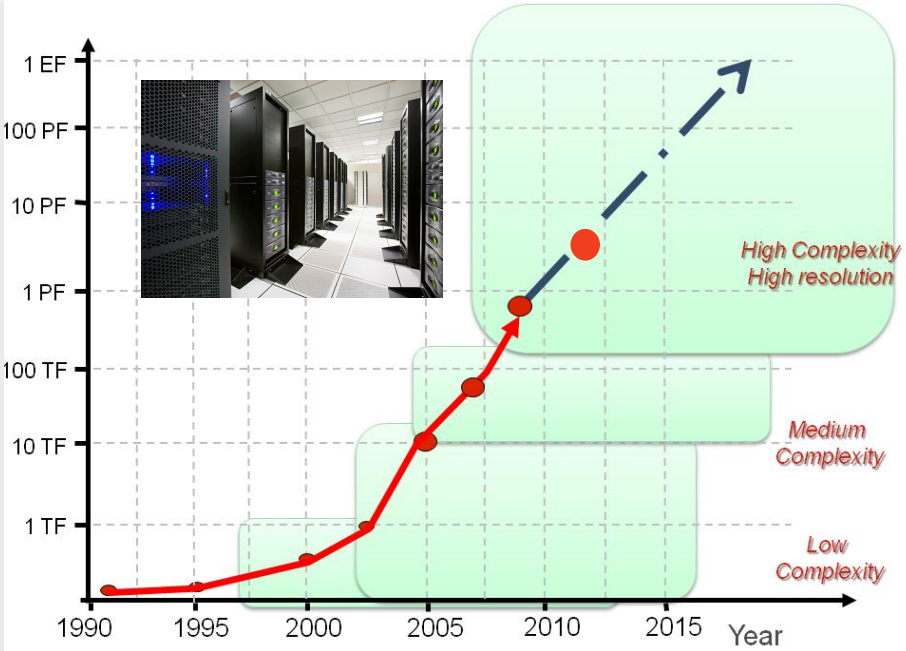
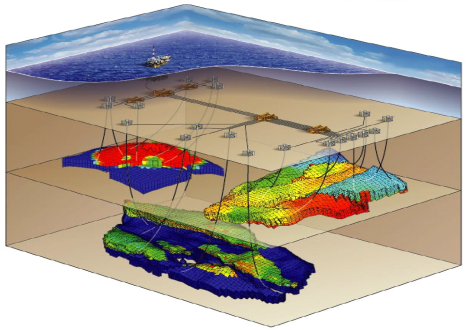
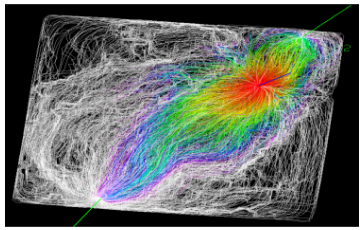
Taking advantage of computing capailities

- Computing power has increased by a factor of ***1000*** in the past ten years
- Larger seismic data set can be processed : Giga bytes in 2000 Tera bytes today (***x by 1000***)
- Larger reservoir models can be simulated : 100 Kgrid cell models in 2000, 1G models today (***x by 10000***)

⇒Access to unprecedent level of integration from seismic to network modelling







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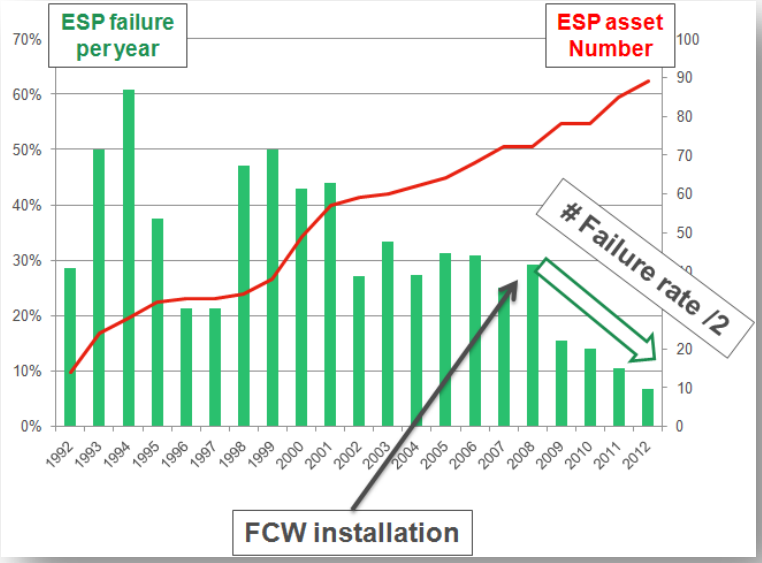
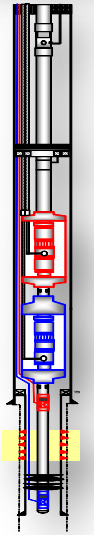
Production Optimization Operations

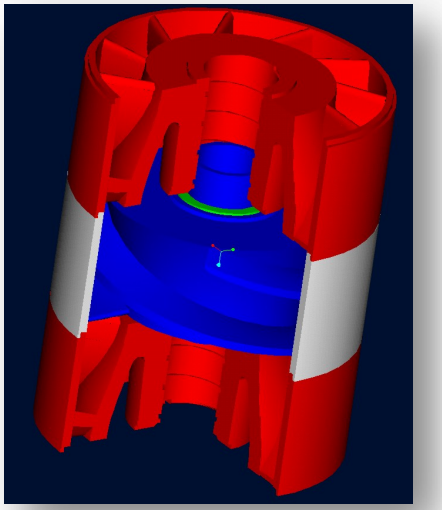
No limits with Technology

Artificial lift technologies for improving production systems

- ***Artificial lift*** **necessary to produce wells in mature oil fields due to pressure decline or water breakthrough**
- ***ESP*** **allows to lower flowing pressure and increase production**
- **Some *simple technologies* to improve ESP potential and reliability**
  - Dual ESP
  - ESP Automation
  - Gas handling improvement
  - Wire line retrievable ESPs







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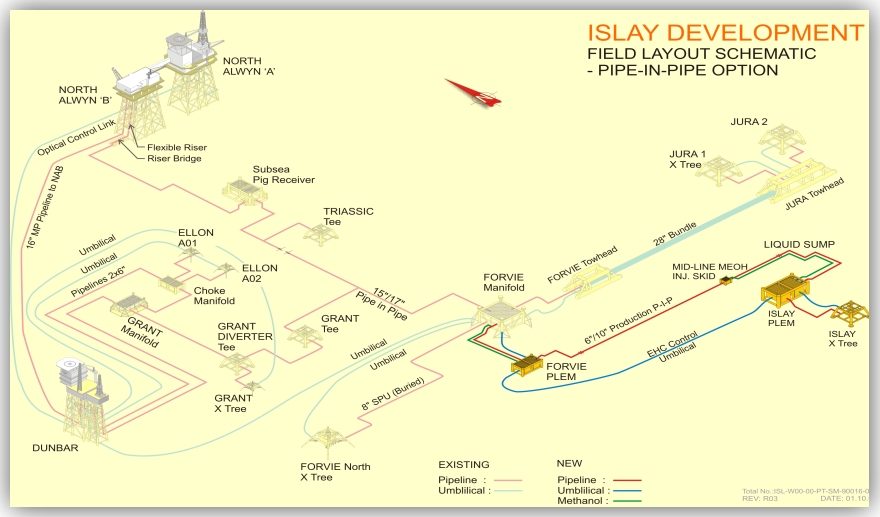
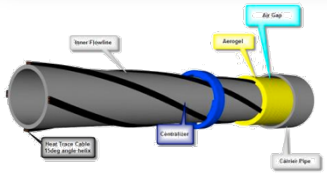
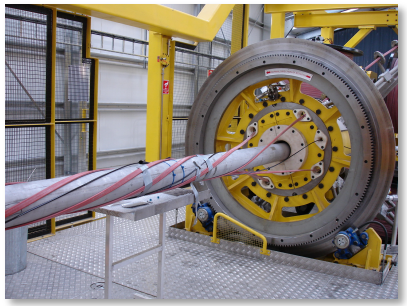
Flow assurance solutions to push the limits of sub-sea tie-backs in mature areas

- ***a sub-sea tie-back*** of a small prospect to an existing manifold (Alwyn area)
- ***Gas Condensate*** production from 1 well
- ***Risk on restart*** following unplaned shut down due to flow assurance issues (Hydrates)
- A standard ***Pipe In Pipe with Heat Trace cables*** and fiber optics

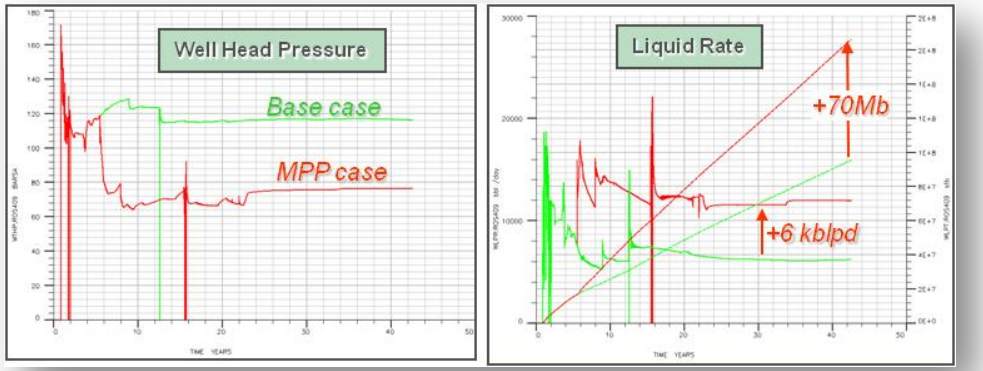


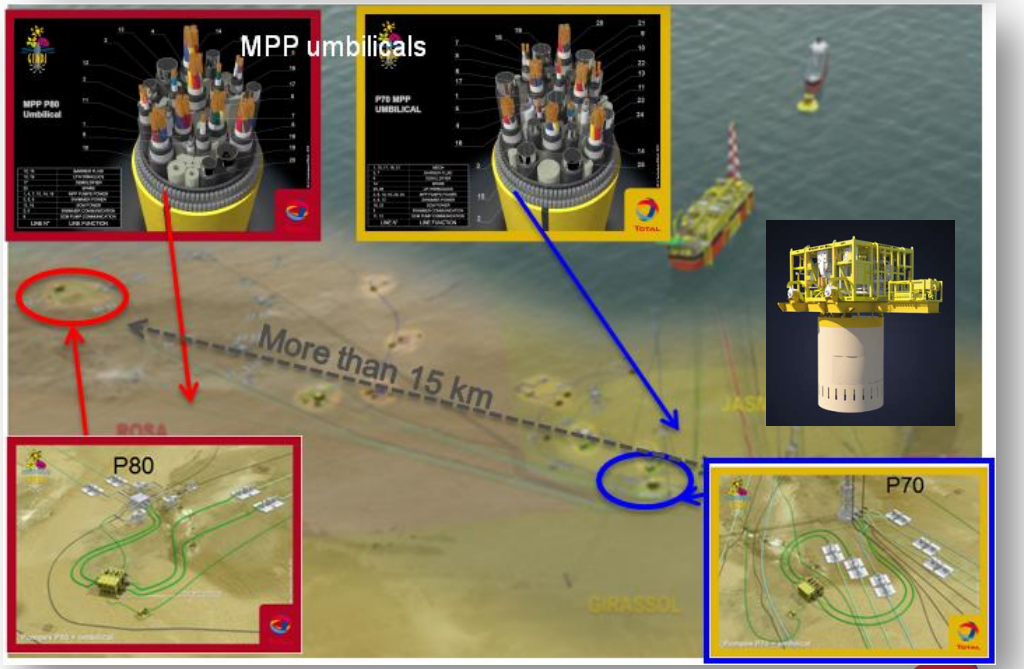




Multiphase High Boost Pumps: the activation solution for a long subsea tie-back

- Objective: ***lower tubing head pressure*** to increase liquid rate and reach higher BSW. Field reserves increased by 10 %
- World first, ***deepwater*** (1,400 m) high boost MPP
- ΔP up to ***130 bar with GVF*** ranging from 0% to 100% (70% in normal operation)
- High-level ***monitoring*** (MPFM, sensors…) for 'live' pump operation. Modular design for easier maintenance





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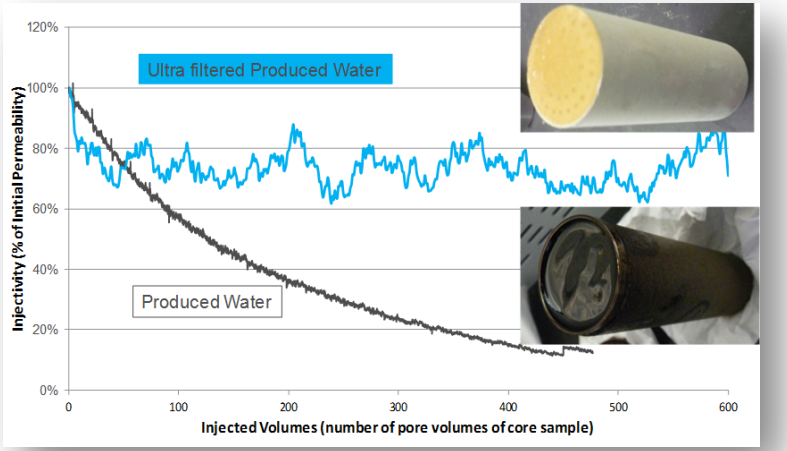
Water treatment technologies to preserve the environment

- On average, every barrel of oil produced involves the handling of more than three barrels of water
- ***Produced Water Re-Injection*** (PWRI) : prefered option for environmental considerations but requires efficient filtration methods to maintain injectivity
- Filtration of Produced Water with ***Ceramic membranes*** (filtration threshold below 0.1 micron).



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Technology is a key enabler to get more value from hydrocarbon fields

… but the real challenge is understanding how to make the most of it!

“It was not the radar that won the Battle of Britain, but the organization that was developed around it"

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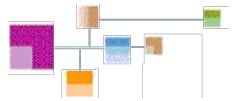

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