




U N I V E R S I T Y O F B E R G E N

Department of Physics and Technology

Research for More Sustainable Oil and Gas Production

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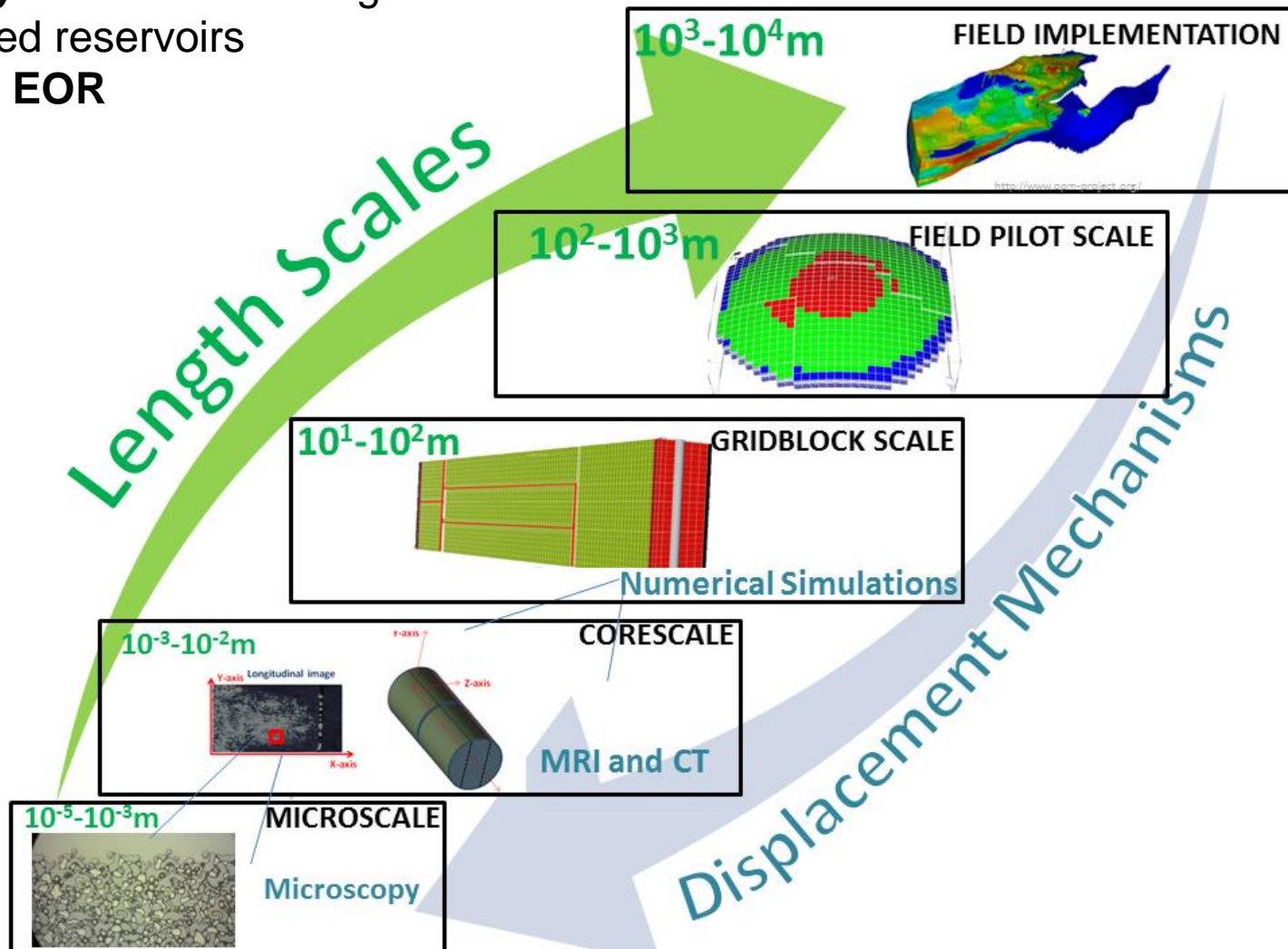


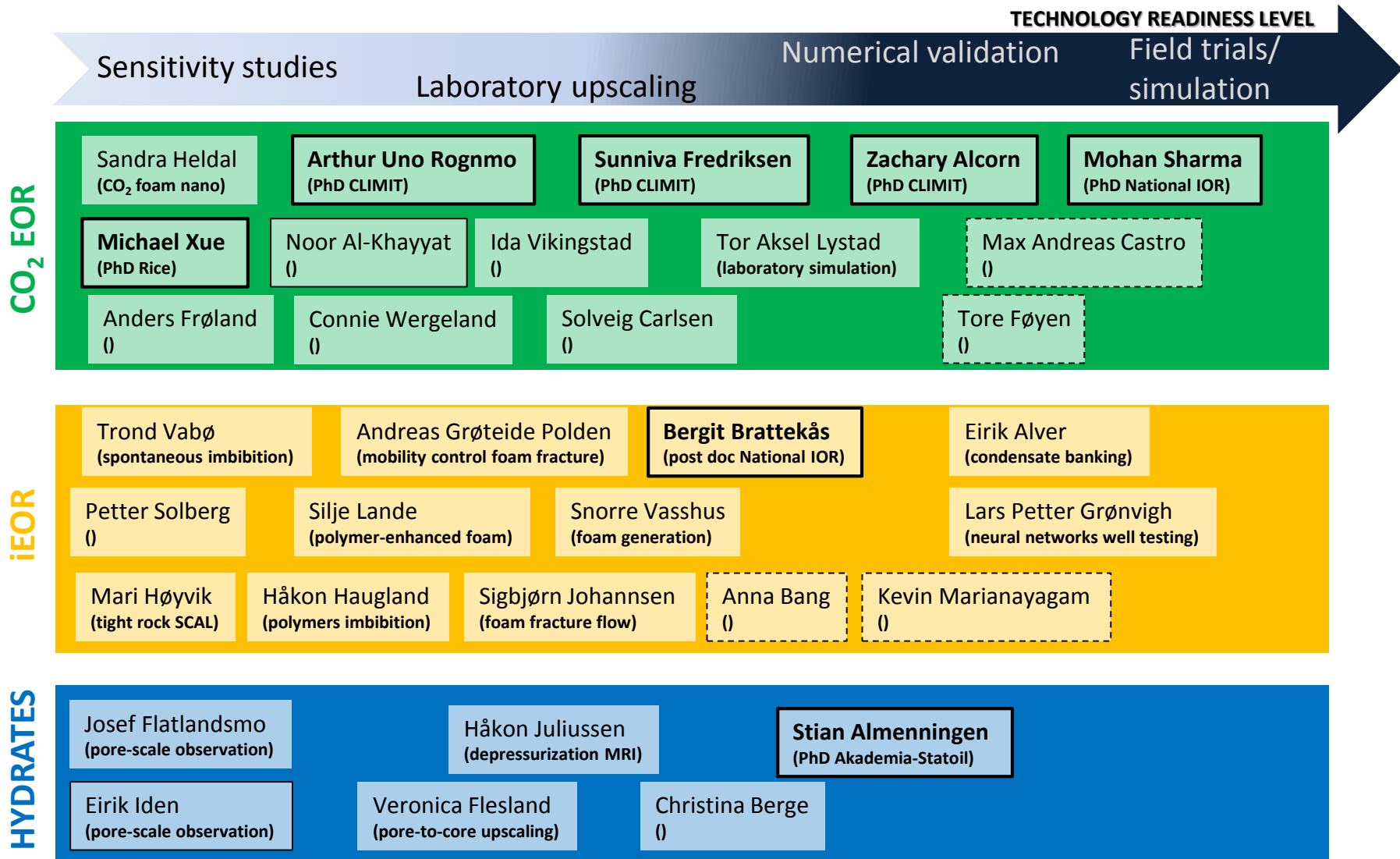
Martin Fernø
Associate Professor
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Department of Physics and Technology
University of Bergen

2016 Force seminar, Stavanger, Feb 2-3

Agenda and Research Approach

Present study part of an ongoing multi-scale approach for **mobility control** in heterogeneous and fractured reservoirs during **CO₂ EOR**





Key Scientific and Administrative Personnel RESERVOIR PHYSICS RESEARCH AND STUDENT ACTIVITIES 2016

Professor Arne Graue

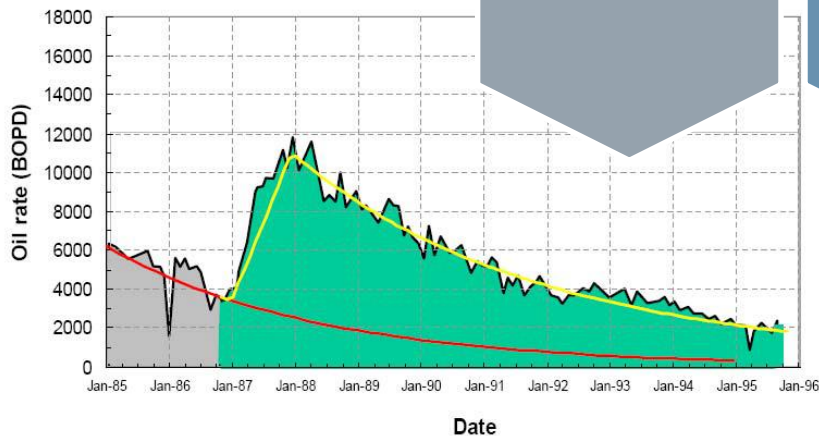
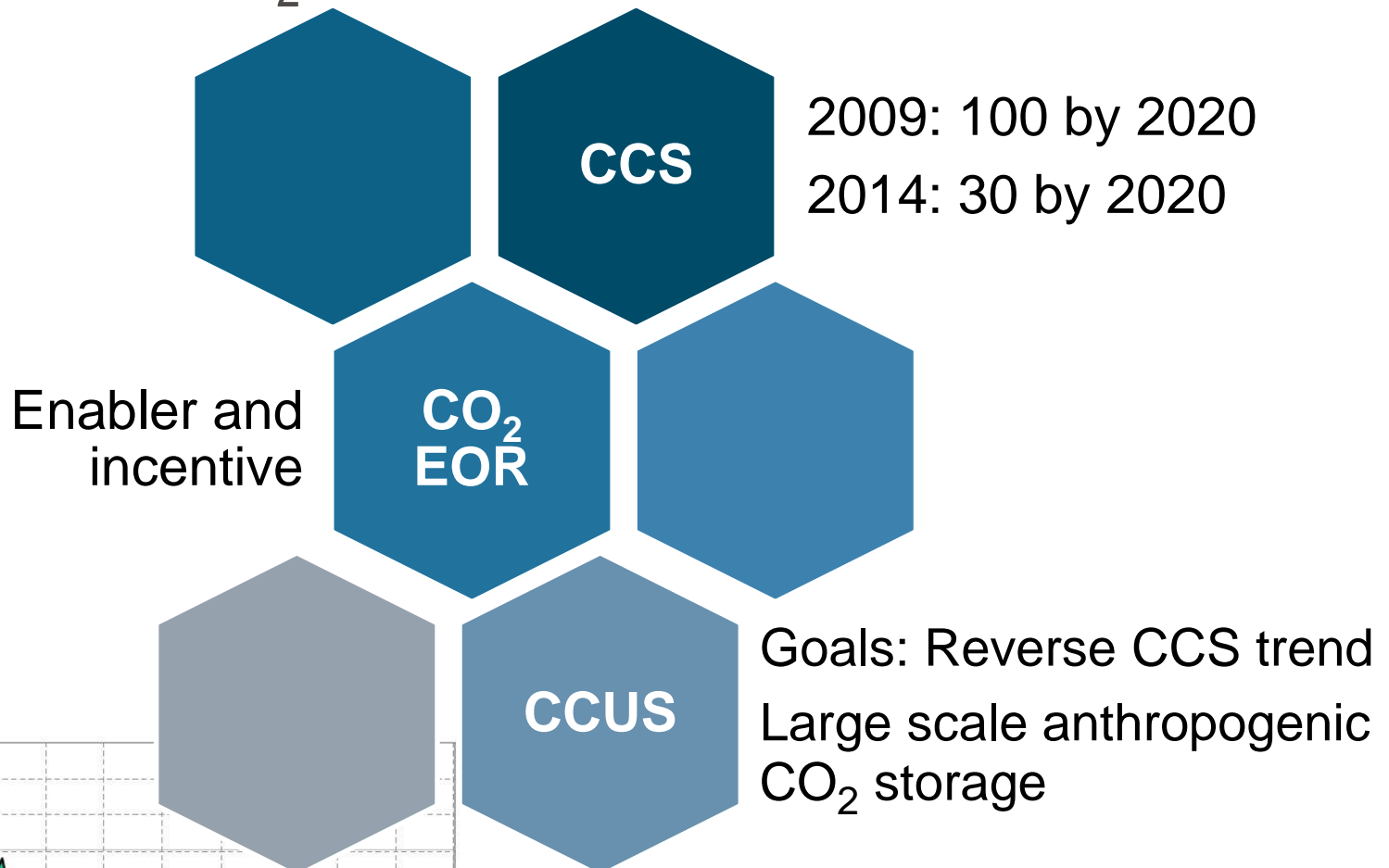
Associate Profs. Martin A. Fernø and Geir Ersland

Chief Technician Marianne Steinsbø

Lab assistant Inez Buzdugan



Motivation for CO₂ EOR



Waterflood vs CO₂ EOR
Wyoming, USA



Advantages with CO₂ for EOR injection

LOW
MMP

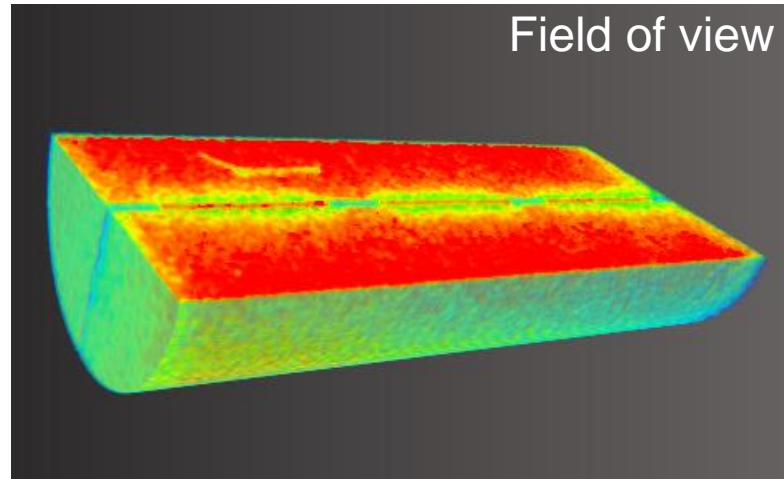
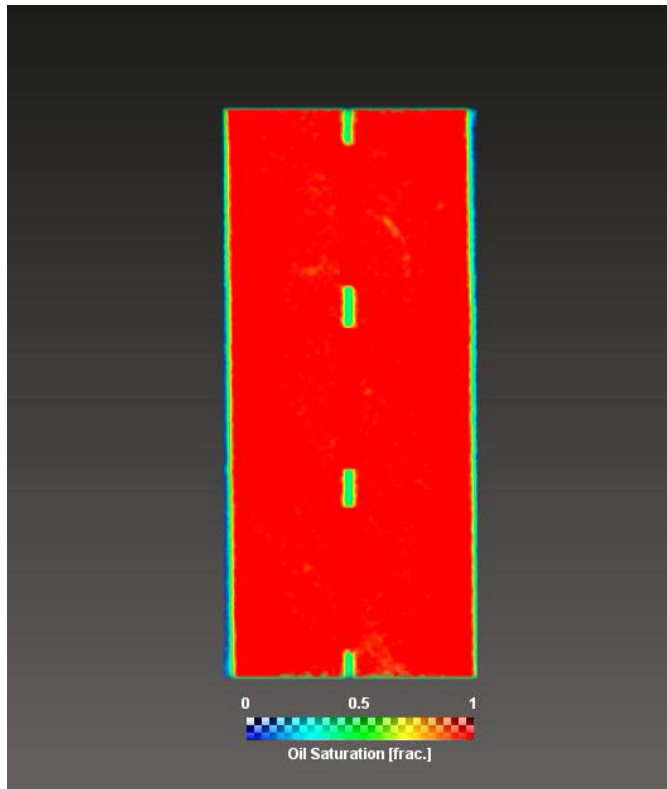
Oil
viscosity

Swelling

CO₂
storage



Supercritical CO₂ injection

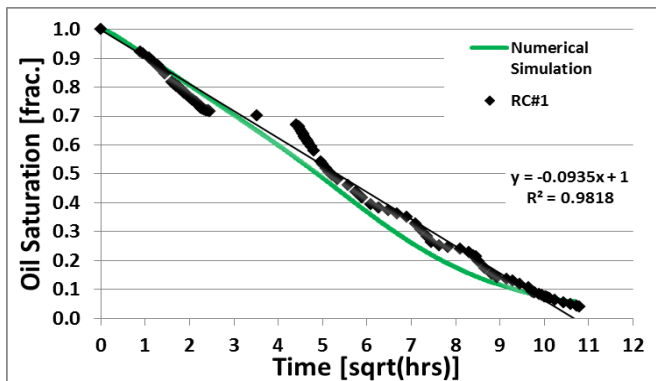


Rock properties

Core K: 3.6 mD, Core Por: 0.45

Fracture K: > 2 D, $S_o=1.0$

$R_F=96\%$ OOIP



Challenges with CO₂ for EOR injection

Corrosion

Availability

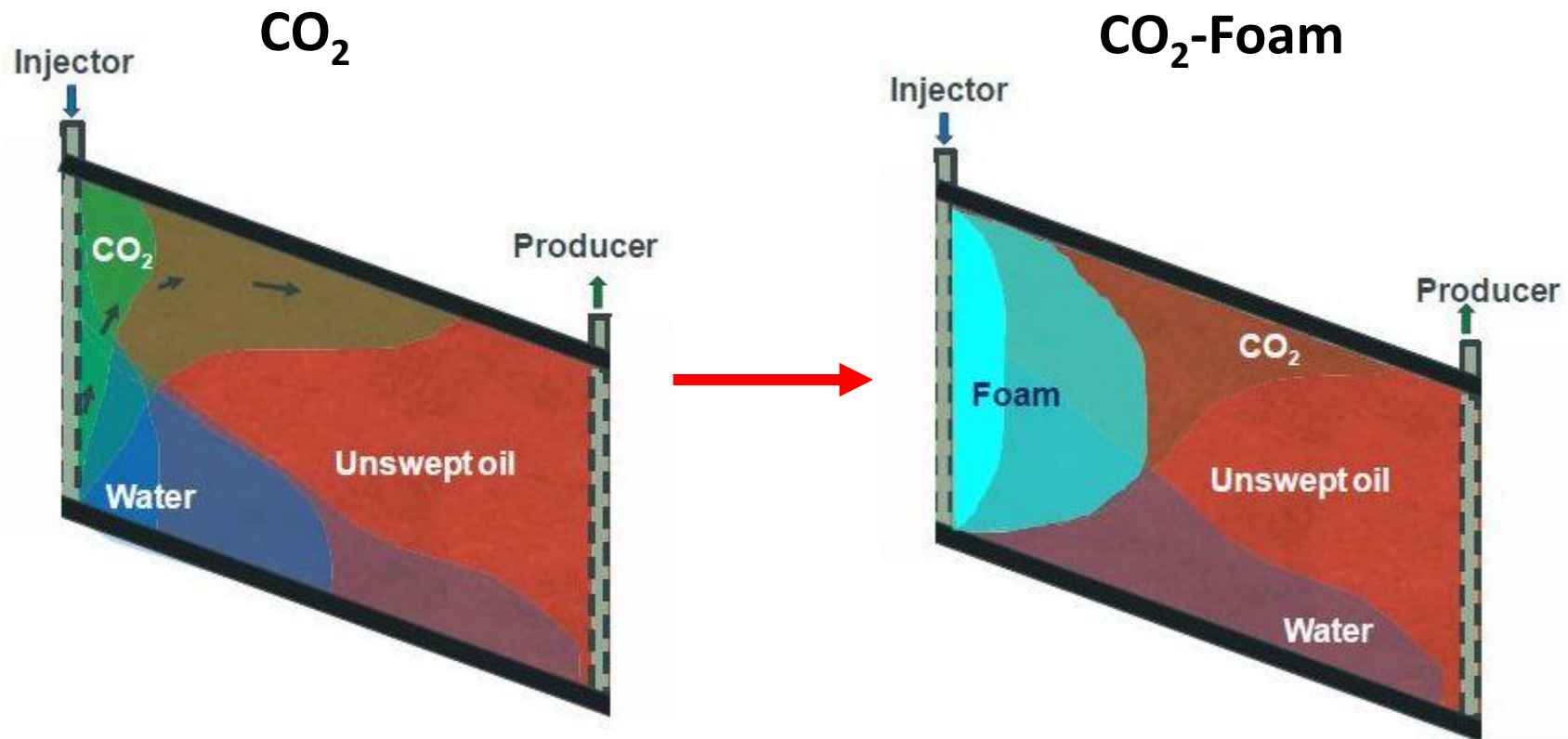
Low
viscosity

Recycling

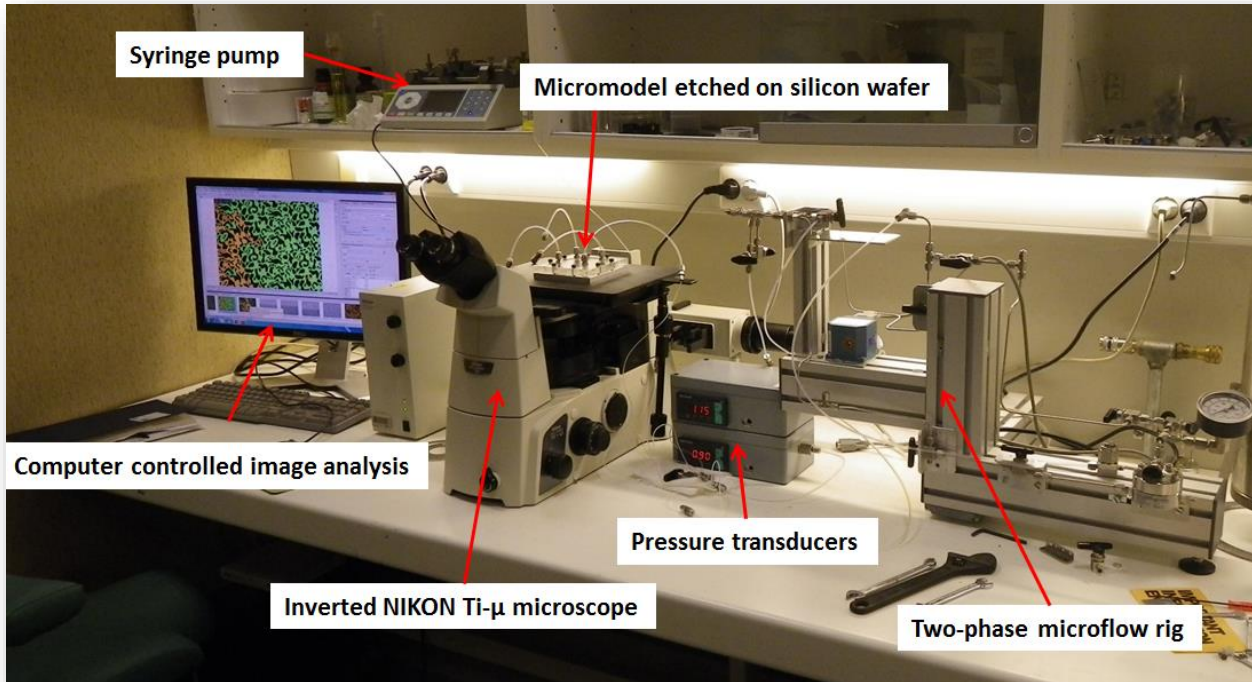


CO₂-foam

- Mitigates gravity override
- Improves sweep efficiency



PORE SCALE MOBILITY CONTROL WITH FOAM



SALIENT FEATURES

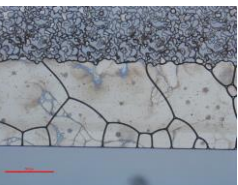
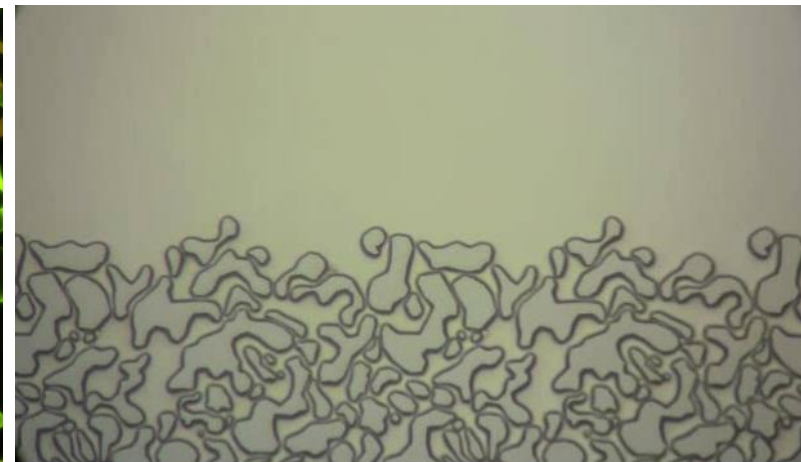
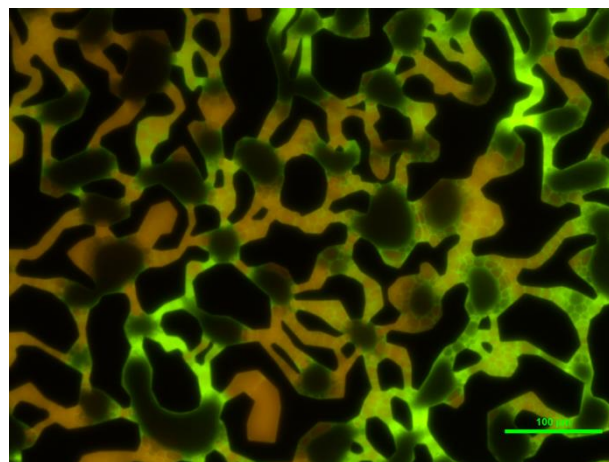
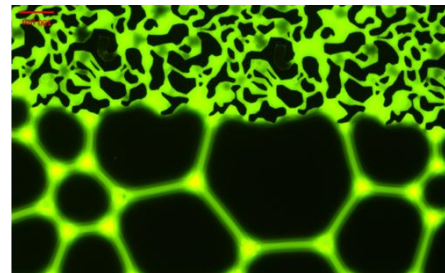
HIGH pressure
 ACCURATE pore space
 FRACTURE transport possible

SPECIFICS

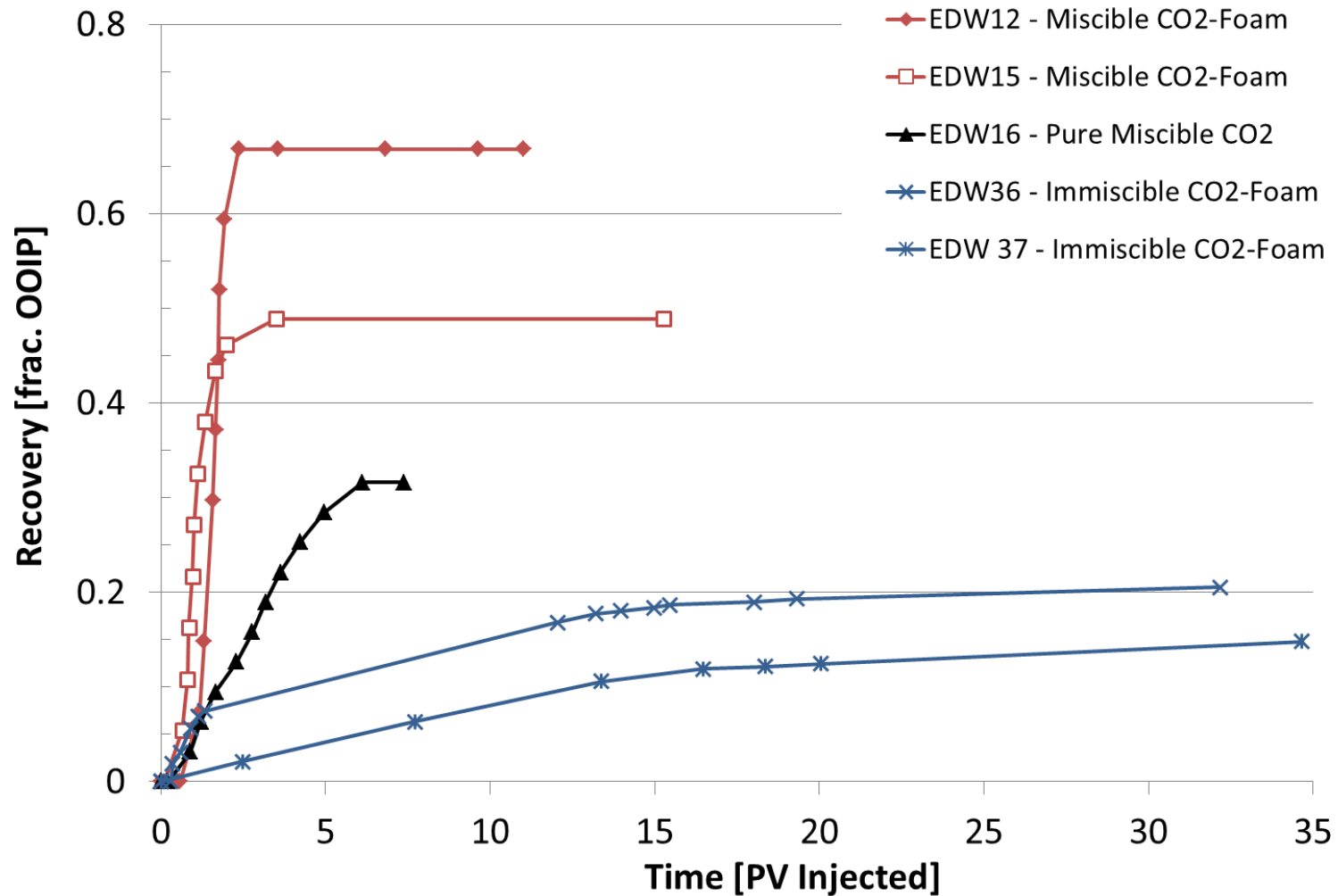
25 μ m constant depth
 (typical pore size in sandstone)

Coordination numbers
 4-8 (high pressure models)
 1-6 (low pressure models)

Initial wetting is water-wet



Supercritical CO₂ Foam injection



CO₂ foam field pilot project

OBJECTIVE

Cost-effective “Roadmap for Success” for mobility control CO₂ EOR implementation on Norwegian Continental Shelf through onshore field trials in Texas

WHY TEXAS?

- CO₂ is commercially available
- Foam as mobility control
- Up-scaling; major challenge in oil recovery
- Fraction of costs of off-shore field tests
- Fast results: short inter-well distances
- 30 years experience in Texas on CO₂ EOR
- 4D seismic establishes a field laboratory

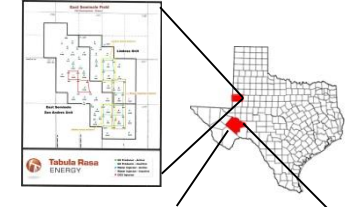
COLLABORATORS

University of Bergen	Total	Stanford University
University of Bordeaux	Rice	National IOR centre
University of Houston	TU Delft	Schlumberger
Statoil	UT Austin	Shell

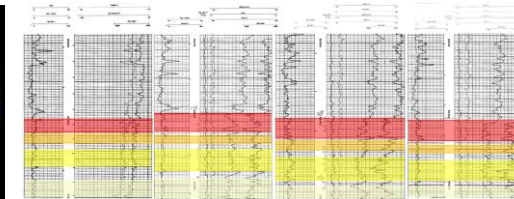
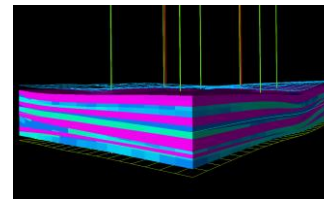
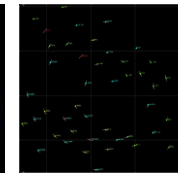
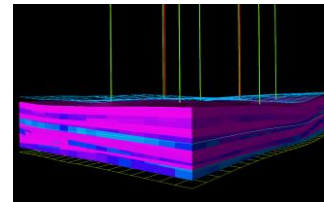
FUNDING

Norwegian Research Council, CLIMIT program
Oil Industry (Shell, Total, Schlumberger, Statoil)
+ local independent operators

East Seminole Well Location Map



Ft. Stockton Well Location Map



STATUS

- Hired 5 PhDs (3 UiB, 1 UiS, 1 Rice)
- Industry/Academic research clusters
- Geological models in Petrel
- Coring of new wells
- History matching waterflooding
- CO₂ injection ongoing
- Optimization of injection rates
- Identifying 5-spot for CO₂-foam
- Surfactant for CO₂ foam found

Other experimental EOR/IOR activities

Without CO₂

- Polymer Gels for conformance control
- Spontaneous imbibition
- Polymer injection in unconsolidated sand
- Integrated EOR
- Low Quality Chalk Reservoirs
- Low salinity IOR

With CO₂

- Nanoparticle stabilization
- CO₂ injection for EOR in Shale oil
- CO₂ storage in saline aquifers
- CO₂ injection for gas production in hydrates



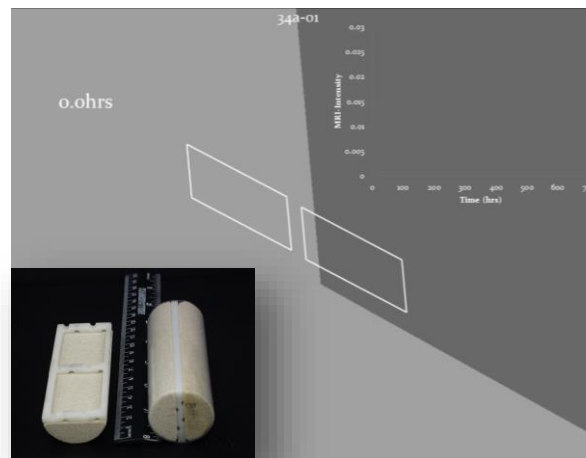
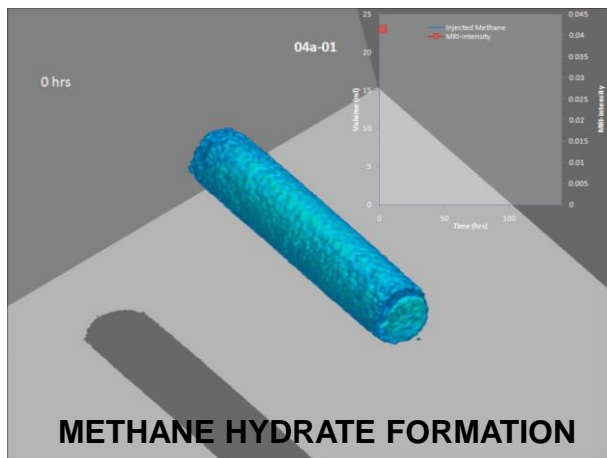
Energy for the Future

CO₂ Sequestration in Hydrates with Associated Gas Production

RESEARCH MOTIVATION

Energy bound in hydrates is more than combined energy in conventional oil, gas and coal reserves

Laboratory Verification of CO₂/CH₄ Exchange Through MRI imaging



BENEFITS

Simultaneous gas production and CO₂ sequestration

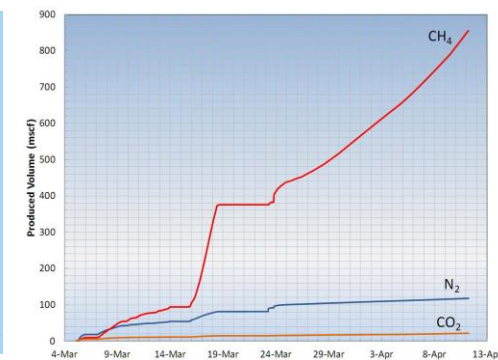
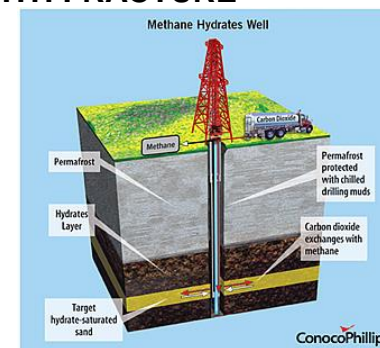
Need no hydrate melting or heat stimulation

Spontaneous process and formation integrity

No associated water production

STATUS

- Alaska Field Injection Test 2011-2012
- ConocoPhillips, US DOE and JOGMEC
- US\$11.6 mill funding from US DOE
- Total cost ca. US\$30mill



Other CCUS Activities

NorTex Petroleum Cluster NORTEX PETROLEUM CLUSTER

1st Biennial CO₂ for EOR as CCUS Conference, Houston, USA Nov 19-21, 2013

2nd Biennial CO₂ for EOR as CCUS Conference, Houston, USA Oct. 4-6, 2015

The 2015 CO₂ for EOR as CCUS Conference gathered

120 registered attendees from **43 different organization**

A total of 60 graduate students participated;

20 from Norway and UK and 40 from 9 different universities in the USA
(USC, Stanford, CSM, UT, TAMU, Rice, UH, KU and UND).

Website: www.nortexpetroleum.org



Chairman Arne Graue, Mike Moore, Chuck McConnell, Vello Kuuskraa, Steve Melzer and Fred Eames

Petroleum Research School of Norway

(UiB, UiS, NTNU, UiT, UiO, UNIS)

2013 Oneday seminar at the Petroleum Museum, Stavanger Nov 24th
Emphasizing More Sustainability in Upstream Petroleum Activities

Website: www.NFiPweb.org

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