CO2 Foam EOR Field Pilots in Texas and Mississippi

by

Arne Graue
Dept. of Physics and Technology
University of Bergen, NORWAY

2nd Biennial CO2 for EOR as CCUS Conf., Houston, TX, Oct. 4-6th, 2015
Next Generation CO$_2$ Flooding

- Main challenges in CO$_2$ EOR:
  - Early CO$_2$ breakthrough and poor sweep efficiency
  - Up-scaling laboratory EOR to field performance

- US White Paper:
  - Mobility control in CO$_2$ EOR, USDOE/Advanced Resource International Inc.
  - Target: 137 Billion bbl

- US import of foreign oil may be reduced by 30%

- “Next generation CO$_2$ EOR technology” based on mobility control

- 68 billion barrels of oil: 1,35 billion bbl of oil every year for 50 years

- Similar results in the North Sea; pilot in the Snorre Field

- Economic at oil price of US$ 85 and CO$_2$ price of US$ 40/ton

- Need more CO2

- Carbon Capture Utilization and Storage (CCUS) a win-win situation
Oil-Wet Carbonate Core Plugs: IEOR (WF + CO$_2$ + CO$_2$-foam)

EDW 16
$I_{AH} = -0.15$
$S_{wi} = 0.17$
$\Phi = 24.4\%$
Matrix perm = 18.1 mD
Fracture perm = 319 mD
Injection Rate = 3 ml/hr
Oil-Wet Carbonate Core Plugs: IEOR (WF+CO$_2$-foam)

- **EDW 15**
  - $I_{AH} = -0.06$
  - $S_{wi} = 0.11$
  - $\Phi = 26.3\%$
- Matrix perm = 45.4 mD
- Fracture perm = 401 mD
- Injection Rate = 16 ml/hr
Comparison between miscible CO$_2$ injection and immiscible and miscible CO$_2$-foam
Upscaling:

- Field Pilots
- Grid Block
- Large Volume Blocks
- Core Plugs
- Micromodels
Is this what oil is supposed to look like?
CO$_2$ Foam for Mobility Control for EOR in Fractured Reservoirs in Texas

Project advantages:

- CO$_2$ is commercially available
- Foam as mobility control
- Researchers from 11 reputational universities
- 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 CO$_2$ EOR
- 4D seismic establishes a field laboratory
Large Scale Collaboration Emphasizing Mobility Control and CO2 EOR in Field Pilots in Texas

Collaboration: 11 universities
- Rice University
- University of Texas at Austin
- Texas A&M U.
- Stanford U.
- Imperial College, London
- TREFLE, Bordeaux, France
- U. of Kansas
- New Mexico Tech
- TU Delft, The Netherlands
- NTNU, Trondheim, Norway
- University of Bergen, Norway
**EOR Enables CCUS:**

*Integrated EOR (IEOR) for CO₂ Sequestration*

**CO₂ Foam for Mobility Control for EOR in Fractured Reservoirs in Texas**

**Collaboration:** 11 Universities in France, The Netherlands, UK, USA and Norway

**Coordinator:** Arne Graue, Dept. of Physics, University of Bergen, NORWAY

**Funding:** The Research Council of Norway and oil companies

Integration of Geology, Mathematical Modeling and Laboratory Experiments

Lab to pilot field test

MRI of CO₂ injection

Complementary NTI & MRI facilities
NorTex Partners:

4 Universities in Texas, USA
- Rice University, Houston, TX, USA
- University of Houston, Houston, TX, USA
- University of Texas at Austin, Austin, TX, USA
- Texas A&M University, College Station, TX, USA

3 Universities in Norway:
- University of Bergen, Bergen, Norway
- University of Stavanger, Stavanger, Norway
- NTNU, Trondheim, Norway

Industry Board Members
- Statoil Petroleum ASA, Schlumberger, OneSubsea

Industry Partners
- Denbury, Natl. Oil Well Varco, FMC, Kinder Morgan, Hess, BP, Total, Oxy, Shell, Wintershall, Tabula Rasa, American Res. and Chevron
NorTex Petroleum Cluster Board Members and Deputies

**Elected Chairman of the Board:**
Prof. Arne Graue, Dept. of Physics and Technology, U. of Bergen, Norway  
Deputy: Prof. Tor Arne Johansen, Dept. of Earth Science, U. of Bergen, Norway

**Board Members:**
Prof. Jon Olson, Department Chair, Dept. of Petr. and Geosystems Eng., UT at Austin, TX, USA  
Deputy: Prof. Ron Steel, UT at Austin, TX, USA.

Prof. Dan Hill, Department Head, Dept. of Petr. Eng., Texas A&M Univ., TX, USA.  
Deputy: Assoc. Prof. David Schecther, Dept. of Petr. Eng., Texas A&M Univ., TX, USA.

Svenn Ferry Utengen, Vice President Unconventional, Texas Area, Statoil, USA.  
Deputy: Bruce Tocher, Manager Unconventional Hydrocarbons, Texas Area, Statoil, USA.

Najib Abusalbi, Corporate University Relations Manager, Schlumberger, Houston, TX, USA

Prof. George Hirasaki, Dept. of Chemical and Biomolecular Eng., Rice U., TX, USA.  
Deputy: Ass. Prof. Lisa Biswal, Dept. of Chem. and Biomolecular Eng., Rice U., TX, USA.

Prof. Tom Holley, Director, Petr. Eng. Program, U. of Houston, TX, USA.  
Deputy: Mike Nikolaou, Assoc. Prof. of Chemical Engineering, University of Houston

Prof. Svein Skjæveland, Dept. of Petr. Eng., U. of Stavanger, Norway  
Deputy: Assoc. Prof. Merete Madland, Dept. of Petr. Eng., U. of Stavanger, Norway

Prof. Martin Landrø, Dept. of Petr. Eng. and Applied Geophysics, NTNU, Norway  
Deputy: Prof. Ole Torsæter, Dept. of Petr. Eng. and Applied Geophysics, NTNU, Norway
Thank you!