

Improved Oil Recovery – the importance of research and academia

- Research and education for IOR
- History and plans

by Svein M. Skjæveland, University of Stavanger

History-1

In 1969, 50 years ago, the Ekofisk field was discovered and Rogaland Regional College was founded. The Norwegian Oil Directorate and Statoil came 3 years later. Until 1969, Stavanger could offer no college degrees. There were no petroleum engineering schools in Norway and, of course, no Norwegian research expertise to help increase the oil and gas recovery.

Permanent Ekofisk facilities for 300,000 STB/D process facilities were operational in May 1974, the year that Rogaland Research Institute was founded and the first bachelor degree petroleum engineers graduated from the College.

History-2

The Ekofisk reservoir pressure went through the bubble point in 1976 and the gas-oil ratio increased. Rogaland Research started petroleum engineering research. The next year, in 1977, the master's program in petroleum engineering was initiated at the College. These were pioneering, frontier years, with a dash of the wild Norwegian West: We officially conferred masters degrees (cand.techn.) without any consent from the Ministry of Education.

Improved recovery studies and favorable water imbibition results prompted a decision in 1983 to waterflood the northern part of the Ekofisk field with seawater. At that time, by Royal Decree and negotiated by the Research Council, two petroleum research centers were established in Norway. The one at Rogaland Research included the drilling rig, but also projects for improved oil recovery.

History-3

Water injection started in 1987 and favorable waterflood response prompted fieldwide waterflood expansion and injection capacity was increased to 820,000 BWPD. The master's program at the College had now officially been sanctioned and Rogaland Research moved their offices down by the drilling rig area.

Reservoir compaction and seabed subsidence continued to be of concern in the Ekofisk reservoir management strategy. A 1992 field study suggested to minimize future seabed subsidence by arresting pressure decline with pressure maintenance. Due to the age of the Ekofisk facilities and continued seabed subsidence, a decision was made in 1994 to gradually phase out existing facilities and install a new wellhead platform and new process and transportation facilities. At that time, the Stavanger University College was formed by the merger of 7 schools, and Rogaland Research spawned a subsidiary in Bergen.

History-4

Drilling from the new Ekofisk wellhead platform started in October 1996. The new process and transportation facilities were commissioned in August 1998. Stavanger University College was granted the privilege of conferring doctorate degrees and started the final drive for university status.

The development of the Ekofisk field, including the research centers like Corec, has run parallel to and sometimes intertwined with the development of Rogaland Research to an internationally recognized institute, and the College to the University of Stavanger.

History-5

I think it is fair to say that without the support from the oil industry, it had been, and still will be difficult to develop high caliber academic institutions in this region of sufficient momentum to permanently establish Stavanger as a student and university city.

Approaching the present

The government established the university of Stavanger in 2004 and it was formally opened by King Harald in 2005. Its vision or motto is “We will challenge the well-known and explore the unknown,” which is fairly close to the ONS 2018 theme “Innovate”.

Educational Programs in Technology (2018)

Academic life at the University of Stavanger is organised into six faculties, comprising a total of 13 departments/schools and two National Research Centres, as well as the Museum of Archaeology.

Faculty of Science and Technology

- Department of Chemistry, Bioscience and Environmental Engineering
- Department of Electrical Engineering and Computer Science
- Department of Energy and Petroleum Engineering
- Department of Energy Resources
- Department of Mathematics and Physics
- Department of Mechanical and Structural Engineering and Materials Science
- Department of Safety, Economics and Planning

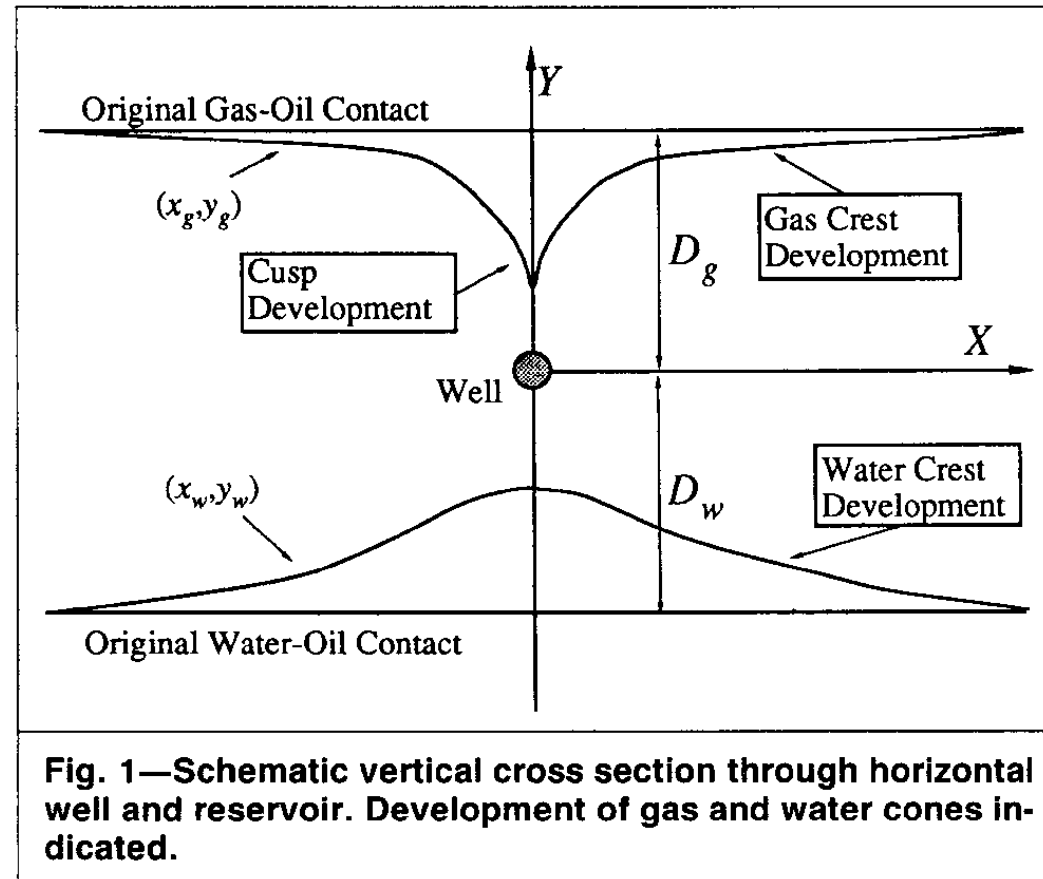
The Research is organized in Departments and Centers

Samples of Journal Papers:

Cone Breakthrough Time for Horizontal Wells

Paul Papatzacos, Rogaland U.; T.R. Herring, SPE, Fina Exploration Norway; Rune Martinsen, SPE, Enterprise Oil Norge Ltd.; and S.M. Skjaeveland, SPE, Rogaland U.

SPE Reservoir Engineering, August 1991



Two-Phase Pressure Test Analysis

Arld Bø SPE, Rogaland Research Inst., and **Svein M. Skjæveland**, SPE, and **Curtis H. Whitson**, SPE, Rogaland U.
SPE Formation Evaluation, December 1989

Capillary Pressure Correlation for Mixed-Wet Reservoirs

S.M. Skjaeveland, SPE, **L.M. Siqveland**, and **A. Kjosavik**, SPE, Stavanger College; **W.L. Hammervold Thomas**, SPE, Statoil; and **G.A. Virnovsky**, SPE, RF-Rogaland Research
SPE Reservoir Eval. & Eng. **3** (1), February 2000

IOR Center Disseminations the first 6 months of 2018

General publications (newspapers, popularizations): **13**
Conferences and meetings: **81**
Scientific Journal Papers: **39**

The Research is organized in the Departments and special Centers

The National IOR Centre of Norway

Host: UiS

Research partners: IRIS and IFE

Collaborators: UNIVERSITY OF BERGEN; UNIVERSITY OF OSLO; NTNU / UGELSTAD LABORATORY; SINTEF; DTU / GEO / GEUS; TNO; TU DELFT; CORNELL UNIVERSITY; UT AUSTIN; INSTITUTE FOR THE STUDY OF THE EARTH'S INTERIOR (ISEI), JAPAN; TU BERGAKADEMIE FREIBERG, INSTITUTE FÜR MINERALOGIE; ECOLE POLYTECHNIQUE PARIS; UNIVERSITÉ DE LYON; NATIONAL CENTER FOR ATMOSPHERIC RESEARCH (NCAR), USA; UNIVERSITY OF STUTTGART; UNIVERSITY OF WYOMING; MEMORIAL UNIVERSITY OF NEWFOUNDLAND (MUNF); CHINA UNIVERSITY OF PETROLEUM, BEIJING

Supported by **User partners, RCN, UiS**

Budget: About 50 MNOK/yr during 5+3 yrs

Start: Dec 2013

THE CENTRE BACKGROUND-1

The world needs energy. Up to present day oil and gas have contributed to the primary energy by more than 80 %, and even in the 2-degree scenario of the United Nations more than 50 % of the total energy needs to come from oil and gas. On the

Norwegian Continental Shelf, more than 50 % of the total discovered resources are still left in the ground. There is a great environmental benefit of extracting most of the discovered resources, as existing infrastructure can be used.

The National IOR Centre of Norway provides cost efficient and environmentally friendly solutions for improved oil recovery on the Norwegian Continental Shelf through academic excellence and close cooperation with the industry.

THE CENTRE BACKGROUND-2

The Centre was awarded by the Research Council of Norway in 2013, after a national competition, for 5+3 years with a midterm evaluation.

University of Stavanger is the host of The National IOR Centre of Norway, the research institutes IRIS (now NORCE after merger on 1 January 2018) and IFE are research partners. Several other national, international research groups, and 12 oil and service companies, complete the Centre's list of partners and collaborators.

The researchers in the Centre work actively in order to improve the recovery, whilst reducing costs and mitigating environmental impact. To achieve this goal, it is important that all stakeholders work together, and The National IOR Centre of Norway is an important arena for doing exactly this.

THE CENTRE BACKGROUND-3

OVERALL AIM

The Centre will contribute to the implementation of cost efficient and environmentally friendly technologies for improving oil recovery on the Norwegian Continental Shelf.

SECONDARY OBJECTIVES

- Robust upscaling of recovery mechanism observed on pore and core scale to field scale, instigating pilots (water injection in the Ekofisk field, horizontal wells in the Troll oil zone).
- Optimal injection strategies based on total oil recovered, economic and environmental impact.
- **Education of 20 PhD students and 8 postdocs during the lifetime of the Centre.**



**The National
IOR Centre
of Norway**

The Skjæveland Award, at yearly conference, poster presentation

From the left (2017):

PhD students Oddbjørn M. Nødland, Mona Wetrhus Minde from The National IOR Centre of Norway and Han Byal Kim from Memorial University of Newfoundland got respectively The Skjæveland Award and the prize for «Best Young Presenter under 30».



The 2018 user partners and observers



The organization



Niels Lindeloff
Head of Technical
Committee



Thierry Lauprete
Chairman of the Board



Merete Vadla Madland
Centre Director



Aksel Hiorth
Research Director
Leader Theme 1



Randi Valestrand
Research Director
Leader Theme 2



Sissel Opsahl Viig
Director of Field
Implementation



Svein M. Skjæveland
Director of Academia &
Research



Arne Stavland
Leader Task 1
Core scale



Udo Zimmermann
Leader Task 2
Nano/submicron scale



Espen Jettestuen
Leader Task 3
Pore scale



Aksel Hiorth
Leader Task 4
Upscaling



Tor Bjørnstad
Leader Task 5
Tracer technology



Robert Klöfkorn
Leader Task 6
Reservoir simulation



Geir Nævdal
Leader Task 7
Field scale evaluation

Organizational structure 2018

Chairman of the Board: Thierry Laupretre, Aker BP

Head of Technical Committee: Niels Lindeloff, Total

Centre Director: Merete Vadla Madland, UiS

THEME 1: MOBILE AND IMMOBILE OIL AND EOR METHODS,
AKSEL HIORTH, UIS/IRIS

THEME 2: MOBILE OIL – RESERVOIR CHARACTERISATION TO IMPROVE VOLUMETRIC SWEEP,
RANDI VALESTRAND, IRIS

TASK 1: CORE SCALE, ARNE STAVLAND, IRIS

TASK 2: MINERAL FLUID REACTIONS AT NANO / SUBMICRON SCALE, UDO ZIMMERMANN, UIS

TASK 3: PORE SCALE, ESPEN JETTESTUEN, IRIS

TASK 4: UPSCALING AND ENVIRONMENTAL IMPACT, AKSEL HIORTH, UIS/IRIS

TASK 5: TRACER TECHNOLOGY, TOR BJØRNSTAD, IFE

TASK 6: RESERVOIR SIMULATION TOOLS, ROBERT KLÖFKORN, IRIS

TASK 7: FIELD SCALE EVALUATION AND HISTORY MATCHING, GEIR NÆVDAL, IRIS

Management team

Merete Vadla Madland,
Centre Director

Aksel Hiorth, Director Of
Research

Randi Valestrand, Director Of
Research

Sissel Opsahl Viig, Director Of
Field Implementation

Svein M. Skjæveland, Director
Of Academia



THE CENTRE BOARD (2018)

- **Chairman:** Thierry Laupretre, Aker BP
- Niels Lindeloff, Total
- Steinar Kristiansen, Wintershall
- Per Øyvind Seljebotn, Lundin
- Randi Elisabeth Hugdahl, Statoil
- Øystein Lund Bø, University of Stavanger
- Erlend H. Vefring, IRIS
- Martin Foss, IFE
- **Observers:**
- Ingrid Anne Munz, Research Council of Norway
- Anders Soltvedt, Norwegian Petroleum Directorate
- Erik Søndena, Petoro

TECHNICAL COMMITTEE (2018)

- **Head of committee:** Niels Lindeloff, Total E&P Norge AS
- Andrea Reinholdtsen, Neptune Energy Norge AS
- Bjørn Gulbrandsen, Lundin Norway AS
- Roar Kjelstadli, Aker BP ASA
- Robert Moe, ConocoPhillips Scandinavia AS
- Steinar Kristiansen, Wintershall Norge AS
- Amare Mebratu, Halliburton AS
- Lars Sønneland, Schlumberger Norge AS
- Siroos Salimi, Eni Norge AS
- Knut Uleberg, Equinor ASA
- Johanna Ravnås, DEA Norge AS

The Scientific Advisory Committee

From the left:

Professor Yu-Shu Wu, Petroleum Engineering Department at Colorado School Of Mines

Professor Stephan Herminghaus, Max Planck Institute for Dynamics and Self-organization, University of Göttingen

Professor William R. Rossen, Reservoir Engineering Department of Geoscience and Engineering, Delft University of Technology

Professor Ann Muggeridge, Reservoir Physics and EOR, Dept. of Earth Science and Engineering, Imperial College London



Conclusion and recommendations from the midterm evaluation panel of the Centre in 2017:

This is a strong and highly performing Centre. In this first period the Centre has carried out high quality scientific research that has been externally recognised by international awards. The panel makes following recommendations.

Note: The RCN in April 2018 extended the IOR Centre by 3 yrs.

Summary Evaluation of The SAC committee 2017

In summary, the committee continues to be impressed by the scope and achievements of the research combining both fundamental and applied research in the laboratory and computationally. The Centre is clearly more than the sum of its parts and we are delighted to see cross-theme projects being initiated. The technical quality and overall publication record is also very good, but there should be continued emphasis on publication in peer-reviewed journals and increased emphasis on publicizing the best specific scientific advances made by Centre Researchers each year.

For more info: <http://www.uis.no/ior>

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