

### **Brief Bio Sketch of Professor Abbas Firoozabadi**

Abbas Firoozabadi has published over 150 Journal papers in petroleum interfaces, thermodynamics of hydrocarbon reservoirs and production, and multiphase-multispecies flow in permeable media. He has published mainly in the Society of Petroleum Engineers (SPE) Journals, AIChE Journal, Journal of Chemical Physics, Journal of Physical Chemistry B, Langmuir, Water Resources Research, Advances in Water Resources, Soft Mater, and Journal of Computational Physics. He has authored a graduate text, "Thermodynamics of Hydrocarbon Reservoirs," published by McGraw Hill in 1999. The second edition of the book with major expansion will become available in mid 2012. Firoozabadi is the most prolific author of the Society of Petroleum Engineers (SPE) Journals with over 70 SPE Journal papers. He is also the most published author in petroleum engineering in comparison to faculty members and scientists in petroleum engineering in the US. He has two patents, one related to wettability alteration to intermediate gas wetting, and another patent for use of alcohols as co-surfactants for dispersion of the solid phase in flowlines.

Firoozabadi's major contributions include theoretical, experimental and advanced computational methods in thermodynamics, and kinetics of flow assurance in hydrocarbon energy production. His current research focus includes higher-order numerical models to allow accurate evaluation of CO<sub>2</sub> subsurface injection. In the last several years Firoozabadi has focused on nano-technology concepts in oil and gas flowlines. He has directed research efforts and provided insight in three of the potentially world largest scale CO<sub>2</sub> injection projects. Firoozabadi has recently expanded his research into shale gas mostly based on molecular modeling.

Firoozabadi has received three of the four major awards of SPE. These awards include the SPE/AIME Anthony Lucas Gold Medal (highest technical award), the SPE Honorary Membership Award, and the SPE John Franklin Carll Award, in recognition of setting the stage and new directions for petroleum production and environmental stewardship of hydrocarbon energy production. He was elected to the National Academy of Engineering in 2011.

## Major Contributions

Firoozabadi established his research consortium in 1990. It has evolved as the most productive Joint Industry Project (JIP) in petroleum engineering in comparison to a single faculty project in the United States. From the interactions with various energy, energy service, and specialty chemical companies, critical issues of hydrocarbon energy production and environmental stewardship are abstracted and then attached in a focused and unified approach unique in the modern petroleum industries. Nearly all major oil, oil service, and specialty chemical companies including ExxonMobil (from US), Saudi Aramco (from Saudi Arabia), Petrobras (from Brazil), Schlumberger (from UK office), Japex (from Japan), and Lubrizol (from US) and some 12 other companies support his reach in addition to federal and other research agencies. As a result of the unique interactions which he has enjoyed with the scientists and engineers of the energy and chemical industries, important issues of real-world problems of hydrocarbon reservoirs and production such as non-equilibrium and irreversible phenomena and kinetics, which in the past seemed extremely complicated, have been resolved and formulated. A major dimension of Firoozabadi's research and his research consortium is the use of a unified approach for the study of different types of problems. As an example, wettability in hydrocarbon reservoirs, hydrate kinetics in pipelines, and kinetics of CO<sub>2</sub> sequestration in oceans are all studied using concepts from surface thermodynamics. A second example is the successful application of the potential theory for the study of the gravitational potential variation of the sun and the moon for the estimation of in-situ compressibility and permeability of hydrocarbon reservoirs, and the measurement electrophoretic mobility of asphaltene particles for studying asphaltene precipitation in production facilities and pipelines. Another example is the use of irreversible thermodynamics for the prediction of composition variation in the vertical and horizontal direction in hydrocarbon reservoirs, the deposition of wax in pipelines, and the effect of diffusion in gas injection in fractured petroleum reservoirs, and gas recycling in fractured gas condensate reservoirs. The recent work on development of working equations for the simultaneous measurement of molecular and thermal diffusion coefficients in non-ideal multicomponent mixtures using laser beams of different wavelengths is another example of emphasis on fundamentals and modern techniques to solve complex problems of importance in energy production and environmental stewardship.

Dr. Firoozabadi has served as a consultant to several major oil and chemical companies in the US, Europe, Japan, and South America. In addition to advanced consulting, Abbas has made tireless appearances and given numerous lectures at technical meetings in the US and abroad, and has frequently visited and lectured at nearly all the upstream technology centers of oil companies throughout the world to transfer advanced technology to the petroleum production industry. In addition to giving graduate seminars at the Petroleum Engineering Departments of Stanford University, University of Texas-Austin, Texas A&M University, Tulsa University, Norwegian University of Science and Technology, Delft University of Technology, he has also given graduate seminars at Cambridge University, University of Tokyo, Imperial College London, MIT, Rice University, Princeton University, University of Michigan-Ann Arbor, Yale University, University of Maryland, Peking University, Tsinghua University, Waseda University, and the King Abdullah University of Science and Technology (KAUST) and a number of

other US and European universities on the effectiveness of irreversible and non-equilibrium thermodynamics in formulation and solution of problems in hydrocarbon reservoirs and production.

Professor Firoozabadi has developed and taught various courses in chemical and petroleum engineering in Iran, advanced gas engineering at Stanford University, advanced thermodynamics at the University of Texas-Austin, at Imperial College London, and at Yale University in New Haven. He has also taught intensive advanced courses on thermodynamics (for many years together with Professor Prausnitz of the University of California-Berkeley) and gas engineering at the Norwegian University of Science and Technology in Trondheim, Campinas State University in Brazil, Curtin University of Technology in Australia, and the Autonomous University of Mexico (UNAM). A survey of the advanced gas engineering course by 15 Stanford graduate students was valued at the 95th percentile at Stanford's School of Engineering. He has supervised the research work of ten Ph.D. students. His past PhD students have positions at IMP (Mexico), University of Wyoming, Texas A&M University, ExxonMobil, Chevron, and Halliburton. He is currently advising three Ph.D. students at Yale University. He has supervised a large number of post docs in the last 22 years. His recent post docs have positions at Shell, Schlumberger, ConocoPhillips, Eni, Chevron, University of Calgary, and Stanford University.

A summary of some of his specific achievements and contributions to chemical and petroleum engineering in the areas of thermodynamics and flow in the subsurface are provided in the following.

## **Thermodynamics of Hydrocarbon Energy Production**

### **1. Bulk-Phase Equilibrium Thermodynamics**

Firoozabadi introduced cubic equations of state for phase behavior calculation of reservoir fluids in a 1977 SPE paper co-authored with the late professor Donald Katz of the University of Michigan. This widely cited paper set the stage for large scale compositional reservoir simulation in the oil industry. He also introduced a multisolid wax model for phase behavior calculation of wax precipitation from petroleum fluids in a 1996 AIChE Journal paper co-authored with Dr. Lira-Galeana of IMP and Professor John M. Prausnitz of the University of California, Berkeley. The widely cited work has been implemented in commercial software. The papers by Firoozabadi and coworkers on the use of a micellization model for asphaltene precipitation from crudes published in the AIChE Journal and SPE Journals have received considerable citation and have advanced asphaltene precipitation predictions. He is recently advanced phase behavior of water and CO<sub>2</sub> and precipitation of asphaltenes by cross-association with considerable success.

### **2. Efficient Computations of Phase-Split and Thermodynamic Stability Testing**

The papers published in SPE, AIChE and Fluid Phase Equilibria Journals lay the foundation for robust and efficient computations of phase-split and thermodynamic stability testing and critical-point calculations in multicomponent two- and three-phase states. The use of the reduction space has allowed one to two orders of magnitude decrease in CPU time. The main feature, however, is the robustness of computations for intensive (of the order of billion) phase-split calculations for evaluation of CO<sub>2</sub> and other

gas injection schemes in oil reservoirs and most recently in CO<sub>2</sub> sequestration. The methodology has been incorporated in the new release of Eclipse, the most widely used reservoir simulation software in the world. Very recently Firoozabadi and post doc Dr. Zhidong Li have developed an extremely robust and efficient multiphase-split calculation algorithm to be published in SPE Journal.

### **3. Fickian and Thermal Diffusion in Multicomponent Mixtures from Irreversible Thermodynamics**

Introduction and consistent formulation of diffusion flux expression for thermal, pressure and concentration gradients in multicomponent non-ideal fluids from irreversible thermodynamics are major contributions from Firoozabadi's group. Demonstration of the merit of derivation of Fickian diffusion flux expression from irreversible thermodynamics over the Maxwell-Stephan approach has introduced a major advance. The papers published in I&EC Research and AIChE Journals provide framework for measurement and interpretation of Fickian and thermal diffusion in multicomponent non-ideal fluid mixtures. Formulation has been incorporated in the VIP software from Halliburton. Papers have been widely cited by various groups of engineers, physicists and chemists. Another contribution relates to demonstration that as result of the balance between pressure, Fickian, and thermal diffusion, and convection, there may be conditions under which a heavy fluid may float on top of a light fluid and publication of actual oil field data with oil on top of gas phase.

### **4. Gas Hydrate Driving Force, Kinetics, and Anti-agglomeration, and Asphaltene Nano-particles**

Introduction and consistent formulation of hydrate formation driving force in the hydrate literature. Use of the driving force in the nucleation rate expression and induction time. The papers published in Journals of Crystal Growth and Chemical Physics have been used to interpret hydrate kinetic data and have been singled out in recent reviews as distinct advances in hydrate kinetic modeling. Demonstration of the use of very small quantities of bio-surfactants for hydrate nano-particles in the form of slurries in the environmental stewardship of hydrocarbon production. Delayed sedimentation of asphaltene nano-particles from use of ppm level dispersants.

### **5. Reduction of Surface Energy of Rock Substrate and Intermediate-Gas Wetting**

In 1999, Firoozabadi and coworkers introduced the idea of wettability alteration to intermediate gas wetting for subsurface rocks for the first time. A patent is shared with DuPont on the subject. Contact angles as high as 160 degrees for the water-gas-rock substrate were achieved. Since then, a number of R&D polymers have been synthesized by 3M and DuPont in collaboration with Firoozabadi's group. The energy alteration is permanent and therefore fit for application in gas wells for increased well production rate. There has been much interest in the work partly due to the need to increase natural gas production and the expectation that natural gas may become the premium fuel of the 21<sup>st</sup> century. The papers published in the SPE Journals have been well received. Pilot testing of the idea has been carried out.

## **6. Effect of Curvature on Saturation Pressure**

Development of expressions for calculating the effect of curvature on saturation pressure and interfacial tension for non-ideal multicomponent mixtures and demonstration that saturation pressure and interfacial tension may increase or decrease due to curvature, for the first time. In single component mixtures the saturation pressure always decreases with curvature according to the Kelvin expression. The work has significant application in nucleation modeling of non-ideal multicomponent mixtures (for the study of the kinetics of condensation in the retrograde region in reservoirs and in pipelines, and in hydrate formation).

## **Physics and Mathematics of Subsurface Flow**

### **1. Physics of Multiphase Flow in Fractured Media**

Concepts from thermodynamics and fluid flow are combined in a unique way to introduce fracture capillary in 1990 in two SPE papers for the first time. It was also demonstrated that fracture capillary pressure can be the most important parameter in oil recovery of fractured reservoirs. Shortly after, a rigorous derivation of reinfiltration concept was presented in two SPE papers.

### **2. Numerical Simulation of Complex Flow Problems in Hydrocarbon Reservoirs**

Definitive advance in numerical solutions to the partial diffusion equations and local equilibrium expressions for two-phase multicomponent flow in fractured and heterogeneous media. The combined discontinuous Galerkin and mixed finite element method coupled with physical concepts have allowed incorporation of physics and appropriate mathematical expressions for simulation of CO<sub>2</sub> injection in fractured reservoirs and in sequestration. The methodology is two to four orders of magnitude faster than the software by major oil companies, oil service companies, and national labs. For the first time, diffusion can be studied in fractured media properly. Papers published in Water Resources Research, SPE, AIChE and Advances in Water Resources Journals have set the stage for realistic modeling of CO<sub>2</sub> injection in complex permeable media.

### **3. Large Scale Proposals for Carbon Dioxide Injection**

Based on significant effect of diffusion on change in flow path in fractured porous media, and large reductions in viscosity and increase in swelling, proposals have been accepted by three major oil companies for study and implementation of CO<sub>2</sub> injection for the purpose of improved oil recovery. All projects are very large in scope.

**Abbas Firoozabadi**  
**Reservoir Engineering Research Institute (RERI)**  
**595 Lytton Ave., Suite B, Palo Alto, CA 94301**  
**650-326-9259 phone, 650-326-9277 fax, [af@rerinst.org](mailto:af@rerinst.org) e-mail**

**Yale University, Chemical and Environmental Engineering**  
**Mason Lab, Room 103, New Haven, CT 06520**  
**203-432-4379 phone, [abbas.firoozabadi@yale.edu](mailto:abbas.firoozabadi@yale.edu) e-mail**

## **Personal**

- Married, with two children
- Born 1948: Yazd, Iran

## **Employment**

- 1974-1983 National Iranian Oil Company, Iran
- Assistant Professor of Gas Engineering, Abadan Institute of Technology, Abadan, Iran, 1974-1975, 1977
  - Senior Research Engineer, Tehran, Iran, 1978-1980
  - Senior Researcher and Manager (founder), Petroleum Recovery Research Center, Tehran, Iran, 1980-1983
- 1984-1987 Stanford University, U.S.A.
- Visiting Scholar, Petroleum Engineering Department, 1984-1985
  - Associate Professor (Acting), Petroleum Engineering Department, 1986-1987
- 1988-1989 Norsk Hydro, Norway
- Research Advisor, Exploration and Production Research Center, Bergen
- 1990-present Reservoir Engineering Research Institute, U.S.A.
- Founder and Senior Scientist/Director, 1990-present
- Fall 1996 University of Texas, Austin
- Visiting Professor, Petroleum Engineering and Geosciences Department-taught a new graduate course on “Advanced Thermodynamics of Hydrocarbon Reservoirs”.
- 1998-2011 Imperial College London
- Visiting Professor, Department of Earth Science and Engineering Lectures to PhD students on “Advanced Thermodynamics of Hydrocarbon Reservoirs and Production”. He has supervised four PhD students at Imperial College London.
- 2003-present Yale University, New Haven, USA
- Adjunct Professor, Department of Chemical and Environmental Engineering. Primary responsibilities are teaching of the graduate course “Classical and Statistical Thermodynamics” and supervision of PhD students and post docs.

## Education

- 1970 B.S. Gas Engineering (graduated with honors), Abadan Institute of Technology, Abadan, Iran
- 1972 M.S. Gas Engineering, Institute of Gas Technology, Illinois Institute of Technology, Chicago, IL, U.S.A.
- 1974 Ph.D. Gas Engineering, Institute of Gas Technology, Illinois Institute of Technology, Chicago, IL, U.S.A.
- 1976 Postdoctoral Fellow, University of Michigan, Chemical Engineering Department, Ann Arbor, MI, U.S.A.

## Awards and Honors

- 1988 Journal of Petroleum Technology, Distinguished Author Paper (Phase Behavior)
- 2000 Journal of Canadian Petroleum Technology, Distinguished Author Paper (Fractured Reservoirs)
- 2000 SPE Reservoir Engineering Award
- 2001 Journal of Canadian Petroleum Technology, Best Paper Award
- 2001 Dodge Distinguished Lecture, Yale University
- 2002 Anthony F. Lucas Gold Medal of SPE/AIME (highest technical award of SPE)
- 2004 SPE John Franklin Carll Award
- 2009 SPE/AIME Honorary Member Award
- 2010 AIChE Journal, Author of Invited Perspective Article on CO<sub>2</sub> Sequestration
- 2011 Member, National Academy of Engineering

## Research Interests

Current research interests center on 1) nano-particles in flow assurance in hydrocarbon energy production from onshore and offshore fields, 2) mathematical modeling of multiphase flow in the subsurface based on higher-order methods, 3) molecular modeling of shale gas and shale light oil reservoirs, and 4) diffusion in the critical region in single component and multicomponent mixtures

## Teaching Interests

Four favorite topics are: 1) thermodynamics of multicomponent non-ideal mixtures for both homogenous and heterogeneous media (micelles and microemulsion) and computation of thermodynamic stability and phase splitting, 2) thermodynamics of thin films and interfaces related to energy production and environment, and 3) irreversible thermodynamics with emphasis on energy production and climate change,

and 4) multicomponent-multiphase flow in complex permeable media. Much of the fascination with the first two topics is derived from an in-depth study of the works of Gibbs, and the extent that Gibbs' original ideas and their extension on bulk-phase thermodynamics can be used to solve many physical and computational problems in energy production and environmental stewardship. The second topic provides the basis for the understanding of interfaces and size in many properties, especially in nanoparticles. Irreversible thermodynamics allows a practical solution to many complex problems in the subsurface and better understanding of entropy and entropy production and various diffusion processes. Flow in permeable has most of the notions of the first three topics plus the momentum balance and unique aspects of the solution to non-linear equations.

### **Professional Activities**

- SPE Technical Editor, 1987-2011
- SPE Journal, Board, 1998-2011
- SPE Review Chairman, 1991-1993
- Committee Member of SPE Reservoir Simulation Symposium, 1988
- Committee Member of SPE Forum on Naturally Fractured Reservoirs, 1989
- Committee Member of SPE Western Regional Meeting, 1992
- Chairman of SPE Forum on Reservoir Fluids: Phase Behavior and Physical Properties, 1993
- Committee member of SPE Annual Fall Meeting, 1994-1997
- Session Chairman - "Fractured and Heterogeneous Reservoirs," 1988 Reservoir Simulation Symposium
- Session Chairman - "Field Case Studies," 1989 SPE Forum on Naturally Fractured Reservoirs
- Session Chairman - "Fractured Reservoirs," 1992 SPE Western Regional Meeting
- Member of the SPE Long Term Strategy Committee, 2004-2006
- Member of the Scientific Committee of 2006 International Thermodiffusion Conference, IMT 7, San Sebastian, Spain
- Member of the SPE John Franklin Carll, Anthony F. Lucas Gold Medal, and the Lester C. Uren Awards Committee, 2005-2007
- Member of the AIME 2007-2009 Mineral Economics Award Committee
- Member of the SPE Major Awards Committee, 2010-2012
- Member of the Scientific Committee for the 2010 International Interdiffusion Conference, IMT9, Toulouse, France
- Member of the Scientific Committee of the 2012 International Thermodiffusion Conference, IMT10, Brussels, Belgium

## Consulting

- National Iranian Gas Company, Iran, 1975-1980  
*Various studies on Iranian gas reservoirs and gas pipelines*
- Oil Service Company of Iran, 1977-1980  
*Various studies on Iranian fractured oil reservoirs*
- Norsk Hydro, Norway, 1986-2000  
*Various studies on major oil and gas reservoirs of the Norwegian North Sea.*  
*Studies on all fractured reservoirs of the Ekofisk field*
- Japan National Oil Corporation (JNOC), Japan, 1986-1995
- Mobil Research and Development Company, Dallas, TX, U.S.A., 1987
- Amoco Production Company, Tulsa, OK, U.S.A., 1987, 1992, 1993, 1995
- Petrobras, Brazil, 1990, 1992, 1995
- Oil and Natural Gas Commission, India, 1991, 1993, 1994  
*Development of Ghandahar volatile oil and gas condensate reservoirs (UN Sponsorship)*
- Marathon Oil Company, Denver, CO, U.S.A., 1993
- Union Pacific Resources, Fort Worth, TX, U.S.A., 1993
- Pennzoil Exploration Co., Houston, TX, U.S.A., 1994  
*Evaluation of a very tight fractured oil reservoir*
- Phillips Petroleum Co., Bartlesville, OK, U.S.A., 1995
- Pemex, Mexico City, 1996
- Intevep, Caracas, 1996, 1998
- Pall Corporation, New York, 1997  
*Evaluation of droplet formation in gas pipelines*
- Fina Italy, Milan, 1997  
*Evaluation of the Tempa Rosa fractured field*
- Seven Seas Petroleum Company, Houston, 1999  
*Evaluation of a tight fractured reservoir in Colombia*
- Shell International, Houston, 1999
- PDVSA, Puerto La Cruz, Venezuela, 2000
- Schlumberger, Houston, 2001-2002
- Plus Petrol, Buenos Aires, Argentina, 2002  
*Evaluation of a Complex Gas Condensate Field in Peru*
- Chevron and Schlumberger, San Ramon, CA, 2004-2006  
*Thermodynamic Computations*
- Pemex, Mexico, 2004, 2006  
*Evaluation of Puerto Ciba Abnormally Pressured Reservoir, 2004*  
*Evaluation of the Cantarell group of Fractured Reservoirs, 2006*
- Petrobras, Rio de Janeiro, 2007  
*Irreversible thermodynamics and reservoir connectivity*

- Petrobras, Rio de Janeiro, 2008-2011  
*Carbon dioxide injection and production strategy in giant pre-salt offshore fields*
- Mexican Institute of Petroleum, Mexico City, 2012  
*Numerical Simulation of fractured reservoirs*

## **Patents**

1. Alcohol Co-surfactants in Hydrate Anti-agglomeration  
York, J.D.; Firoozabadi, A. US Provisional Patent Application 61/031199, Renewed 2008, 2009  
Yale University is currently converting it into a full patent application, file date of 03-23-10.
2. Prevention and Remediation of Water and Condensate Blocking in Wells  
Marin C. M., Wu, S., and Firoozabadi, A. Patent Application 12/437572  
Patent filed by DuPont.

## **Publications**

### **I – Book**

Firoozabadi, A.: *“Thermodynamics of Hydrocarbon Reservoirs,”* McGraw-Hill, NY, New York, 1999. Second Edition with extensive expansion to appear in 2012

### **II – Papers**

#### **Refereed Journals**

1. Firoozabadi, A., Hekim, Y. and Katz, D.L.: “Reservoir Depletion Calculations for Gas Condensates Using Extended Analyses in the Peng-Robinson Equation of State,” Canadian Journal of Chemical Engineering (Oct. 1978)610-615, also SPE Reprint Series No. 15 “Phase Behavior” (1981).
2. Katz, D. L., and Firoozabadi, A.: “Predicting Phase Behavior of Condensate/Crude-Oil Systems Using Methane Interaction Coefficients,” Journal of Petroleum Technology (Nov. 1978)1649-1655, also AIME Transactions, Vol. 26(1978), also SPE Reprint Series No. 15 “Phase Behavior” (1981).
3. Firoozabadi, A. and Katz, D. L.: “An Analysis of High Velocity Gas Flow Through Porous Media,” Journal of Petroleum Technology (February 1979)211-216.
4. Firoozabadi, A. and Leipziger, A.: “Bubble Point Measurements for Ternary Systems Containing Nitrogen and Methane with Propane, n-Butane or n-Pentane,” Chemical Engineering Communications (1986)46,311-321.
5. Firoozabadi, A. and Aziz, K., “Analysis and Correlation of Nitrogen and Lean Gas Miscibility Pressure,” SPE Reservoir Engineering Journal (Nov. 1986)575-582.
6. Firoozabadi, A., Katz, D.L., Soroosh, H. and Sajjadian, V.A.: “Surface Tension of Reservoir Crude Oil-Gas Systems Recognizing the Asphalt in the Heavy Fraction,” SPE Reservoir Engineering Journal (February 1988)265-272.
7. Firoozabadi, A., Nutakki, R., Wong, T. and Aziz, A.: “EOS Prediction of Compressibility and Phase Behavior in Systems Containing Water, Hydrocarbons and CO<sub>2</sub>,” SPE Reservoir Engineering Journal (May 1988)673-684.
8. Firoozabadi, A. and Ramey, H.J., Jr.: “Surface Tension of Water-Hydrocarbon Systems at Reservoir Conditions,” Journal of Canadian Petroleum Technology (May-June 1988)41-48.

9. Firoozabadi, A., Soroosh, H. and Hasanpour, G.H.: "Drainage Performance and Capillary Pressure Curves Utilizing a New Centrifuge," Journal of Petroleum Technology (July 1988)913-919.
10. Firoozabadi, A.: "Reservoir Fluids Phase Behavior and Volumetric Prediction Using Equations of State," Distinguished Author Paper, Journal of Petroleum Technology (April 1988)397-406.
11. Firoozabadi, A.: "Author's Reply to Discussion of Reservoir-Fluid Phase Behavior and Volumetric Prediction with Equations of State," Journal of Petroleum Technology (Aug. 1988).
12. Firoozabadi, A. and Hauge, J.: "Capillary Pressure in Fractured Porous Media," Journal of Petroleum Technology (June 1990)784-791, also AIME Transactions, 289(1990).
13. Firoozabadi, A. and Thomas, L.K.: "Sixth SPE Comparative Solution Project: Comparison of Dual-Porosity Reservoir Simulators," Journal of Petroleum Technology (June 1990)710-763.
14. Horie, T., Firoozabadi, A. and Ishimoto, K.: "Laboratory Studies of Capillary Interaction in Fractured/Matrix Systems," SPE Reservoir Engineering Journal (Aug. 1990)353-360.
15. Wong, T., Firoozabadi, A. and Aziz, K.: "The Relationship of the Volume Balance Method of Compositional Simulation to the Newton-Raphson Method," SPE Reservoir Engineering Journal (Aug. 1990)415-422, also AIME Transactions, 289 (1990).
16. Wong, T., Firoozabadi, A. and Aziz, K.: "The Relationship of the Volume Balance Method of Compositional Simulation to the Newton-Raphson Method," SPE 21462 (1990), supplement to SPE 18424, available from SPE, Richardson, TX.
17. Firoozabadi, A. and Aziz, K.: "Relative Permeability From Centrifuge Data," Journal of Canadian Petroleum Technology (Sept.-Oct. 1991)33-42.
18. Firoozabadi, A.: "Author's Reply to Discussion of Capillary Pressure in Fractured Porous Media," Journal of Petroleum Technology (February 1991)236-238.
19. Skuse, B., Firoozabadi, A. and Ramey, H.J., Jr.: "Computation and Interpretation of the Capillary Pressure from a Centrifuge," SPE Formation Evaluation Journal (March 1992)17-24, also AIME Transactions, 293(1992).
20. Bjorlykke, O.P., and Firoozabadi, A.: "Measurements and Computation of Retrograde Condensation and Near-Critical Phase Behavior," SPE Reservoir Engineering Journal (May 1992)271-277.
21. Firoozabadi, A.: "Author's Reply to Discussion of Computation and Interpretation of the Capillary Pressure from a Centrifuge," SPE Formation Evaluation Journal (Sept. 1992).
22. Firoozabadi, A., Ottesen, B. and Mikklesen, M.: "Measurements of Supersaturation and Critical Gas Saturation," SPE Formation Evaluation Journal (Dec. 1992)337-344.
23. Kashchiev, D., and Firoozabadi, A.: "Kinetics of the Initial Stage of Isothermal Gas Formation," Journal of Chemical Physics (March 15, 1993)98(6),4690-4699.
24. Firoozabadi, A., Arbabi, S. and Dindoruk, B.: "Near-Critical Phase Behavior of Mixtures Using Variable Interaction Coefficients," Canadian Journal of Chemical Engineering (February 1994)134-141.
25. Firoozabadi, A. and Ishimoto, K.: "Reinfiltration in Fractured Porous Media - Part 1- One Dimensional Model," SPE Advanced Technology (April 1994)35-44.
26. Firoozabadi, A., Ishimoto, K. and Dindoruk, B.: "Reinfiltration in Fractured Porous Media - Part 2 - Two Dimensional Model," SPE Advanced Technology (April 1994)45-51.
27. Firoozabadi, A., Ishimoto and Dindoruk, B.: "Reinfiltration in Fractured Porous Media - Part 2 - Two Dimensional Model," SPE 28516, supplement to SPE 21798, paper available from SPE, Richardson, TX.
28. Firoozabadi, A.: "Author's Reply to Discussion of Measurement of Supersaturation and Critical Gas Saturation," SPE Formation Evaluation Journal (June 1994)159-160.
29. Firoozabadi, A. and Markeset, T.: "Fracture-Liquid Transmissibility in Fractured Porous Media," SPE Reservoir Engineering Journal (Aug. 1994)201-207.
30. Dindoruk, B., and Firoozabadi, A.: "Liquid Film Flow in a Fracture between Two Porous Blocks," Physics of Fluids (Dec. 1994)3861-3869.
31. Lira-Galeana, C., Firoozabadi, A. and Prausnitz, J.M.: "Computation of Compositional Grading in Hydrocarbon Reservoirs," Fluid Phase Equilibria (Dec. 1994)143-158.

32. Tan, C.T., and Firoozabadi, A.: "Theoretical Analysis of Miscible Displacement in Fractured Porous Media - Part I - Theory," Journal of Canadian Petroleum Technology (February 1995)17-27.
33. Tan, C.T., and Firoozabadi, A.: "Theoretical Analysis of Miscible Displacement in Fractured Porous Media - Part II - Features," Journal of Canadian Petroleum Technology (February 1995)28-35.
34. Firoozabadi, A. and Markeset, T.: "Laboratory Studies in Fractured Porous Media, Part I - Reinfiltration for Gas-Liquid Systems," In Situ (February 1995)1-21.
35. Firoozabadi, A. and Markeset, T.: "Laboratory Studies in Fractured Porous Media, Part II- Capillary Crossflow," In Situ (February 1995)23-39.
36. Arbabi, S., and Firoozabadi, A.: "Phase Behavior Prediction of Reservoir Fluids in the Critical Region," SPE Advanced Technology (March 1995)139-145.
37. Shinta, A., and Firoozabadi, A.: "Equation of State Representation of Aqueous Mixtures Using an Association Model," Canadian Journal of Chemical Engineering (June 1995)367-379.
38. Firoozabadi, A., Thomas, L.K. and Todd, B.J.: "High Velocity Gas Flow in Porous Media," SPE Reservoir Engineering Journal (May 1995)149-152.
39. Dindoruk, B., and Firoozabadi, A.: "Computation of Gas-Liquid Drainage in Fractured Porous Media Recognizing Fracture Liquid Flow," Journal of Canadian Petroleum Technology (Dec. 1995)39-49.
40. Lira-Galeana, C., Firoozabadi, A. and Prausnitz, J.M.: "Thermodynamics of Wax Precipitation in Petroleum Mixtures," AIChE Journal (January 1996)239-248.
41. Correa, A., and Firoozabadi, A.: "Concept of Gravity Drainage in Layered Porous Media," SPE Journal (March 1996)101-111.
42. Victorov, A., and Firoozabadi, A.: "Thermodynamics of Asphaltene Deposition Using a Micellization Model," AIChE Journal (June 1996)1753-1764.
43. Firoozabadi, A. and Kashchiev, D.: "Evolution of Gas Phase in Solution Gas-Drive Process," SPE Journal (Sept. 1996)219-227.
44. Shinta A.A., and Firoozabadi, A.: "Predicting Phase Behavior of Water/Reservoir Crude Systems Using the Association Concept," SPE Reservoir Engineering Journal (May 1997)131-137.
45. Firoozabadi, A., and Prausnitz, J.M.: "Thermodynamics of Wax Precipitation in Petroleum Mixtures," Reply to the Letter to the Editor, AIChE Journal (May, 1997)
46. Dindoruk, B., and Firoozabadi, A.: "Crossflow in Fractured/Layered Media Incorporating Gravity, Viscous, and Phase Behavior Effects," SPE Journal (June 1997)120-135.
47. Firoozabadi, A.: "Author's Reply to the Discussion of Pressure and Volume Evolution in Solution Gas Drive Process," SPE Journal (June 1997)219-229.
48. Firoozabadi, A., Markeset, T., Dindoruk B.: "Viscous Crossflow in Fractured Porous Media," Journal of Canadian Petroleum Technology (Oct. 1997)50-62.
49. Pan, H., Firoozabadi, A., and Fotland, P.: "Pressure and Composition Effect on Wax Precipitation: Experimental Data and Model Results," SPE Production and Facilities Journal (Nov. 1997)250-256.
50. Pan, H., and Firoozabadi, A.: "Complex Multiphase Equilibrium Calculations by Direct Minimization of Gibbs Free Energy Using Simulated Annealing," SPE Reservoir Evaluation and Engineering (February 1998)36-42.
51. Riley, M. F., and Firoozabadi, A.: "Compositional Variation in Hydrocarbon Reservoirs with Natural Convection and Diffusion: Two-Component Single-Phase Fluid," AIChE Journal (February 1998)452-464.
52. Pan, H., and Firoozabadi, A.: "Thermodynamic Micellization Model for Asphaltene Precipitation: Micellar Growth and Precipitation," SPE Production and Facilities Journal (May 1998)118-127.
53. Wu, J., Prausnitz, J., M., and Firoozabadi, A.: "A Molecular-Thermodynamic Framework for Asphaltene-Oil Equilibria," AIChE Journal (May 1998)1188-1199.
54. Shukla, K., and Firoozabadi, A.: "A New Model of Thermal Diffusion Coefficients in Binary Hydrocarbon Mixtures," I&EC Research Journal (Aug. 1998)3331-3342.
55. Pooladi-Darvish, M., and Firoozabadi, A.: "Solution-Gas Drive in Heavy Oil Reservoirs," Journal of Canadian Petroleum Technology (April 1999)54-61.

56. Terez, I., and Firoozabadi, A.: "Water Injection in Water-Wet Fractured Porous Media: Experiments and a New Model Using Modified Buckley-Leverett Theory," SPE Journal (June 1999)134-141.
57. Firoozabadi, A. and Aronson, A.: "Visualization and Measurement of Gas Evolution and Flow of Heavy and Light Oils in Porous Media," SPE Reservoir Evaluation and Engineering (Dec. 1999)550-557.
58. Wu, J., Prausnitz, J., and Firoozabadi, A.: "Molecular Thermodynamics of Asphaltene Precipitation in Reservoir Fluids," AIChE Journal (Jan. 2000)197-209.
59. Pan, H., and Firoozabadi, A.: "Thermodynamic Modeling of Asphaltene Precipitation Inhibition," AIChE Journal (February 2000)416-426.
60. Pan, H., and Firoozabadi, A.: "Thermodynamics Micellization Model for Asphaltene Precipitation from Reservoir Crudes at High Pressures and Temperatures," SPE Production and Facilities Journal (February 2000)56-65.
61. Pooladi-Darvish, M., and Firoozabadi, A.: "Co-current and Counter-Current Imbibition in a Water-Wet Matrix Block," SPE Journal (March 2000)3-11.
62. Ghorayeb, K., and Firoozabadi, A.: "Natural Convection and Diffusion in Fractured Porous Media," SPE Journal (March 2000)11-20.
63. Li, K., and Firoozabadi, A.: "Wettability Alteration to Preferential Gas-Wetness in Porous Media and Its Effects," SPE Reservoir Evaluation and Engineering (March 2000)139-149.
64. Pooladi-Darvish, M., and Firoozabadi, A.: "Experiments and Modeling of Water Injection in Water-Wet Fractured Porous Media," Journal of Canadian Petroleum Technology (March 2000)31-42.
65. Ghorayeb, K., and Firoozabadi, A., "Pressure, Molecular and Thermal Diffusion Flux in Non-Ideal Multicomponent Mixtures," AIChE Journal (May 2000)883-891.
66. Firoozabadi, A., Ghorayeb, K., and Shukla, K.: "Theoretical Model of Thermal Diffusion Factors in Multicomponent Mixtures," AIChE Journal (May 2000)892-900.
67. Ghorayeb, K., and Firoozabadi, A., "Modeling Multicomponent Diffusions and Convection in Porous Media," SPE Journal (June 2000)157-171.
68. Li, K., and Firoozabadi, A., "Phenomenological Modeling of Critical Condensate Saturation and Relative Permeabilities in Gas Condensate Systems," SPE Journal (June 2000)137-147.
69. Firoozabadi, A. and Pan, H.: "Two-Phase Isentropic Compressibility and Sonic Velocity for Multicomponent Hydrocarbon Systems," SPE Reservoir Evaluation and Engineering (Aug. 2000)335-341.
70. Firoozabadi, A.: "Recovery Mechanisms in Fractured Reservoirs and Field Performance," Distinguished Author Paper, Journal of Canadian Petroleum Technology (Nov. 2000)13-17.
71. Chang, E., and Firoozabadi, A.: "Gravitational Potential Variations of the Sun and Moon for the Estimation of Reservoir Compressibility," SPE Journal (Dec. 2000)456-465.
72. Ghorayeb K., and Firoozabadi, A., "Features of Convection and Diffusion in Porous Media for Binary Systems," Journal of Canadian Petroleum Technology (February 2001)21-28.
73. Firoozabadi, A.: "Mechanisms of Solution Gas Drive in Heavy-Oil Reservoirs," Distinguished Author Paper, Journal of Canadian Petroleum Technology (March 2001)15-20.
74. Hamoodi, A., Abed, A.F., and Firoozabadi, A.: "Compositional Modeling of Two-Phase Hydrocarbon Reservoirs," Canadian Journal of Petroleum Technology (March 2001)49-60.
75. Nichita, D., Goual, L., and Firoozabadi, A.: "Wax Precipitation in Gas Condensate Systems," SPE Production and Facilities (Nov. 2001)250-259.
76. Tang, T., and Firoozabadi, A.: "Effect of Pressure Gradient and Initial Water Saturation on Water Injection in Water-wet and Weakly Water-wet Fractured Porous Media," SPE Reservoir Evaluation and Engineering (Dec. 2001)516-524.
77. Firoozabadi, A. and Pan, H.: "Fast and Robust Algorithm for Compositional Simulation: Part I-Stability Analysis Testing," SPE Journal (March 2002)78-89.
78. Kashchiev, D., and Firoozabadi, A.: "Driving Force for Crystallization of Gas Hydrates," Journal of Crystal Growth (2002)241, 220-230.

79. Kashchiev, D., and Firoozabadi, A.: "Nucleation of Gas Hydrates," Journal of Crystal Growth (2002)243,476-489.
80. Goual, L., and Firoozabadi, A.: "Measurement of Asphaltenes and Resins, and their Dipole Moment in Petroleum Fluids," AIChE Journal (Nov., 2002)2646-2266.
81. Tang, T., and Firoozabadi, A.: "Relative Permeability Modification in Gas-Liquid Systems Through Wettability Alteration to Intermediate Gas-Wetting," SPE Reservoir Evaluation & Engineering (Dec.2002)427-436.
82. Kashchiev, D., and Firoozabadi, A.: "Induction Time in Gas Hydrates," Journal of Crystal Growth (2003)250,499-515.
83. Karimi-Fard, M., and Firoozabadi, A.: "Numerical Simulation of Water Injection in Fractured Media Using Discrete Fracture Model and the Galerkin Method," SPE Reservoir Evaluation and Engineering (April 2003)117-126.
84. Tang, T., and Firoozabadi, A.: "Gas and Oil Relative Permeabilities for Solution Gas-Drive in Heavy Oil Reservoirs," SPE Reservoir Evaluation & Engineering (April 2003)70-80.
85. Ghorayeb, K., Firoozabadi, A., and Anraku, T.: "Interpretation of the Unusual Fluid Distribution in the Yufutsu Gas-Condensate Field," SPE Journal (June, 2003)114-123.
86. Tang, T., and Firoozabadi, A.: "Wettability Alteration to Intermediate Gas-wetting in Porous Media at Elevated Temperatures," Journal of Transport in Porous Media (Aug. 2003)52(2),185-211.
87. Pan, H., and Firoozabadi, A.: "Fast and Robust Algorithm for Compositional Modeling: Part II – Flash Computations," SPE Journal (Dec. 2003)380-391.
88. Kashchiev, A., and Firoozabadi, "Analytical Solutions for 1D Countercurrent Imbibition in Water-Wet Systems," SPE Journal (Dec.2003)401-408.
89. Goual, L.,and Firoozabadi, A.: "Experimental Study of the Effect of Petroleum Resins and DBSA Amphiphile on Precipitation from Petroleum Fluids," AIChE Journal ( February 2004)470-479.
90. Monteagudo, J.E.P., and Firoozabadi A.: "Control-volume method for numerical simulation of two-phase immiscible flow in 2D and 3D discrete-fracture media," Water Resources Research (July, 2004)W07405,40,1-20.
91. Anklam, M.R., and Firoozabadi, A.: "Driving force and composition for multicomponent gas hydrate nucleation from supersaturated aqueous solutions," Journal of Chemical Physics (Dec. 15,2004)121(23),11867-11874.
92. Haugen, K.B., and Firoozabadi, A.: "On Measurement of Thermal Diffusion Coefficients in Multicomponent Mixtures," Journal of Chemical Physics (Jan. 1, 2005)122,0145165,1-7.
93. Tang, T., and Firoozabadi, A.: "Effect of GOR, Temperature, and Initial Water Saturation on Solution Gas Drive in Heavy Oil Reservoirs," SPE Journal (March 2005)34-43.
94. Leahy-Dios Bou-Ali, M., Platten, J.K., and Firoozabadi, A.: "Measurements of Molecular and Thermal Diffusion Coefficient in Ternary Mixtures," Journal of Chemical Physics, (2005)122,254502,1-12.
95. Anklam, M. R., and Firoozabadi, A.: "An interfacial energy mechanism for the complete inhibition of crystal growth by inhibition adsorption," Journal of Chemical Physics (2005)123,144708.
96. Hoteit, H., and Firoozabadi, A.: "Multicomponent fluid flow by discontinuous Galerkin and mixed methods in unfractured and fractured media," Water Resources Research (2005)41,W11412,doi:10.1029,1-15.
97. Santiso, E., and Firoozabadi, A.: "Curvature Dependence of Surface Tension in Multicomponent Systems," AIChE Journal (2006)52(1)311-322.
98. Haugen, K., and Firoozabadi, A.: "On the unsteady state species separation of a binary liquid mixture in a rectangular thermogravitational column," Journal of Chemical Physics (February, 2006)124(5)1-10.
99. Hoteit, H., Santiso, E., and Firoozabadi, A.: "An efficient and robust algorithm for the calculation of gas-liquid critical point of multicomponent petroleum fluids," Fluid Phase Equilibria (2006)241,186-195.
100. Hoteit H., and Firoozabadi, A.: "Compositional Modeling by the Combined Discontinuous Galerkin and Mixed Methods," SPE Journal (March 2006)19-34.

101. Hoteit, H., and Firoozabadi, A.: "Simple phase stability-testing algorithm in the reduction method," AICHE Journal (Aug. 2006)52(8),2909-2920.
102. Hoteit H., and Firoozabadi, A.: "Compositional Modeling of Fractured Reservoirs Without Transfer Functions by the Discontinuous Galerkin and Mixed Methods," SPE Journal (September, 2006)341-352.
103. Haugen, K., and Firoozabadi, A.: "On Measurement of Molecular and Thermal Diffusion Coefficients in Multicomponent Mixtures from Laser Beams," Journal of Physical Chemistry B (2006)110,No. 35,17678-17682.
104. Nasrabadi, H., Ghorayeb, K., and Firoozabadi, A.: "Two-Phase Multicomponent Diffusion and Convection in Porous Media for Reservoir Initialization," SPE Reservoir Evaluation and Engineering (Oct., 2006)530-542.
105. Leahy-Dios, A., and Firoozabadi, A.: "Effect of Molecular Shape and Size on Molecular and Thermal Diffusion Coefficients of Binary Mixtures," Journal of Journal of Physical Chemistry B (2007)111(1),191-198.
106. Monteagudo, J., and Firoozabadi, A.: "Comparison of fully-implicit and IMPES formulations for simulation of water injection in fractured and unfractured media," International Journal of Numerical Methods in Engineering (2007)69,698-728.
107. Nasrabadi, H., Hoteit, H., and Firoozabadi, A.: "An Analysis of Species Separation in Thermogravitational Column Filled with Porous Media," Journal of Transport in Porous Media (2007)67(3),473-486.
108. Monteagudo, E.P.,and Firoozabadi, A.: "Control-volume model for simulation of water injection in fractured media: Incorporating matrix heterogeneity and reservoir wettability effects," SPE Journal (September 2007)355-366.
109. Leahy-Dios, A., and Firoozabadi, A.: "A Unified Model for Non-Ideal Multicomponent Molecular Diffusion Coefficients," AICHE Journal (Nov. 2007)53 (11), 2032-2939.
110. Haugen, K., and Firoozabadi, A.: "Transient Separation of Multicomponent Liquid Mixtures in Thermogravitational Columns," Journal of Chemical Physics (Oct. 2007)127, 154507.
111. Fahes, M., and Firoozabadi, A.: "Wettability Alteration to Intermediate Gas-Wetting in Gas-Condensate Reservoirs at High Temperatures," SPE Journal (Dec. 2007)397-407.
112. Hoteit, H., and Firoozabadi, A.: "Numerical Modeling of Two-Phase Flow in Heterogeneous Media with Different Capillary Pressures," Advances in Water Resources (Jan. 2008)31,56-73.
113. Anklam, M.R., York, J.D., and Firoozabadi, A.: "The Effects of Anti-agglomerants on the Interactions between Hydrate Particles," AICHE Journal (February 2008)54(2),565-574.
114. York, J.D., and Firoozabadi, A.: "Comparing Effectiveness of Rhamnolipid Biosurfactant with a Quaternary Ammonium Salt Surfactant for Hydrate Anti-agglomeration," Journal of Physical Chemistry B (2008)112,845-851.
115. Leahy-Dios, A., Zhou, L., and Firoozabadi, A.: "New Thermal Diffusion Coefficient Measurements for Binary Hydrocarbon Mixtures: Viscosity and Composition Dependency," Journal of Physical Chemistry B (2008)112,6442-6447.
116. Hoteit, H., and Firoozabadi, A.: "An Efficient Numerical Model for Incompressible Two-Phase Flow in Fractured Media," Advances in Water Resources (2008)31, 891-905.
117. Banki, R., Hoteit, H., and Firoozabadi, A.: "Mathematical Formulation and Numerical Modeling of Wax Deposition in Pipelines by Using Enthalpy-Porosity Approach and Irreversible Thermodynamics," International of Journal of Heat and Mass Transfer (2008)51, 3387-3398.
118. Noh, M., and Firoozabadi, A.: "Effect of wettability alternation on high velocity flow in water and hydrocarbon blocking in gas reservoirs," SPE Journal (Sep., 2008)298-304.
119. Noh, M., and Firoozabadi A.: "Wettability Alteration in Gas-Condensate Reservoirs to Improve Well Deliverability for Water Blocking," SPE Reservoir Evaluation and Engineering (Aug. 2008)676-685.
120. Hoteit, H., Banki, R., and Firoozabadi, A.: "Deposition and Aging in Flowlines from Irreversible Thermodynamics," Energy & Fuels (2008)22(4), 2693-2706.
121. York, J. D, and Firoozabadi, A.: "Alcohol Co-surfactants in Hydrate Anti-agglomeration," Journal of Physical Chemistry B (2008)112, 10455-10465.

122. Haugen, K., and Firoozabadi, A.: "Composition at the Interface Between Multicomponent Non-Equilibrium Phases," Journal of Chemical Physics (2009)130,084707-1
123. Li, Z., and Firoozabadi, A.: "Interfacial tension of nonassociating puree substances and binary mixtures by density functional theory combined with Peng-Robinson equation of state," Journal of Chemical Physics (2009)130,154108.
124. Hoteit, H., and Firoozabadi, A.: "Numerical Modeling of Diffusion in Fractured Media for Gas Injection and Recycling Schemes," SPE Journal (June, 2009)323-337.
125. Li, Z., Firoozabadi, A.: "Cubic-plus-association (CPA) Equation of State for Water-containing Mixtures: Is 'Cross Association' Necessary?," AIChE Journal, (July, 2009)55(7),1803-1813.
126. Haugen, K., and Firoozabadi, A.: "Mixing of Two Binary Non-equilibrium Phases in one Dimension," AIChE Journal (2009)55(8),1903-1936.
127. York, D., and Firoozabadi, A.: "Effect of Brine on Hydrate Anti-Agglomeration," Energy and Fuels (2009)23,2937-2946.
128. Moreira, L., and Firoozabadi, A.: "Thermodynamic Modeling of the Duality of Linear 1-alcohols as Co-surfactants and Co-solvents in Self-assembly of Surfactant Molecules," Langmuir (2009)25(20)12101-12113.
129. Mikyska, J., and Firoozabadi, A.: "Implementation of Higher-Order Methods for Robust and Efficient Compositional Simulation," Journal of Computational Physics (2010)229,2898-2913.
130. Li, Z., and Firoozabadi, A.: "Modeling Asphaltene Precipitation by *n*-Alkanes from Heavy Oils and Bitumens Using Cubic-Plus-Association Equation of State," Energy and Fuels (2010)24,1106-1113.
131. Li, Z., and Firoozabadi, A.: "Cubic-Plus-Association Equation of State for Asphaltene Precipitation in Live Oils," Energy and Fuels (2010)24,2956-2963.
132. Wu, S., and Firoozabadi, A.: "Effect of Salinity on Wettability Alteration of Porous Media from Liquid wetting to Intermediate Gas Wetting," SPE Reservoir Evaluation and Engineering (2010)228-245.
133. Wu, S., and Firoozabadi, A.: "Permanent Alteration of Porous Media Wettability from Liquid Wetting to Intermediate Gas Wetting," Journal of Transport in Porous Media (2010)85,189-213.
134. Hashmi, S., and Firoozabadi, A.: "Polymeric Dispersants Delay Sedimentation in Colloidal Asphaltene Suspensions," Langmuir (2010)26(11),8021-8029.
135. Li, X., Negadi, L., Firoozabadi, A.: "Anti-agglomeration in Cyclopentane Hydrates from Biosurfactant and Cosurfactant," Energy and Fuels (2010)24,4937-4943.
136. Firoozabadi, A. and Cheng, P.: "CO<sub>2</sub> Sequestration in the Subsurface," Perspective, Invited paper AIChE Journal (2010)56(6),1398-1405.
137. Moortgat, J., and Firoozabadi, A.: "Higher-Order Compositional Modeling with Fickian Diffusion in Unstructured and Anisotropic Media," Advances in Water Resources (2010)33, 951-968.
138. Moreira, L., and Firoozabadi, A.: "Molecular Thermodynamic Modeling of Specific Ion Effects on Micellization of Ionic Surfactants," Langmuir (2010), 26(19),15177-15191.
139. Hashmi, S., and Firoozabadi, A.: "Effect of Dispersant on Asphaltene Suspension Dynamics: Aggregation and Sedimentation," Journal of Physical Chemistry B (2010),114,15780-15788.
140. Wu, S., and Firoozabadi, A.: "Effects of Firing and Chemical Treatments on Berea Permeability and Wettability," Energy and Fuels (2011)25,197-207.
141. Wu, S., and Firoozabadi, A.: "Simultaneous Increase in Gas and Liquid Relative Permeabilities and Reduction of High-Velocity Coefficient from Wettability Alteration," Journal of Canadian Petroleum Technology (2011)50,17-23.
142. Mutoru, J., and Firoozabadi, A.: "Form of Multicomponent Fickian Diffusion Coefficients Matrix," Journal Chemical Thermodynamics (2011)43,1192-1203.
143. Moortgat, J., Sun, S., and Firoozabadi, A.: "Compositional Modeling of Three-Phase Flow with Gravity Using Higher-Order Finite Element Methods," Water Resources Research (2011)47,W05511.
144. Mutoru, W., Leahy-Dios, A., and Firoozabadi, A.: "Modeling Infinite Dilution and Fickian Diffusion Coefficients of Carbon Dioxide in Water," AIChE Journal (2011)57(6), 1617-1627.

145. Mikyška, J., and Firoozabadi, A.: “A New Thermodynamic Function for Phase-Splitting at Constant Temperature and Volume,” *AIChE Journal* (2011) 57(7), 1897–1904.
146. Haugen, K.B., Sun, L., and Firoozabadi, A.: “Efficient and Robust Three-Phase Split Computations,” *AIChE Journal* (2011) 57(9), 2555-2565.
147. Hashmi, S., and Firoozabadi, A.: “Tuning Size and Electrostatics in Non-Polar Colloidal Asphaltene Suspensions by Polymeric Adsorption,” *Soft Matter* (2011) 7, 8384-8391
148. Mustapha, H., Dimitrakopoulos, R., Graf, T., and Firoozabadi, A.: “An Efficient Method for Discretizing 3D Fractured Media for Subsurface Flow and Transport Simulations,” *International Journal for Numerical Methods in Fluids* (2011) 67,651–670.
149. Moreira, L., and Firoozabadi, A.: “Molecular Thermodynamic Modeling of Droplet-type Microemulsions,” *Langmuir* (2012) 28, 1738–1752.
150. Hashmi, S., and Firoozabadi, A.: “Field- and Concentration-Dependence of Electrostatics in Non-polar Colloidal Asphaltene Suspensions,” *Soft Matter* (2012) 8, 1878.
151. Rongy, L., Haugen, K. B., and Firoozabadi, A.: “Mixing from Fickian Diffusion and Natural Convection in Binary Non-equilibrium Fluid Phases,” *AIChE Journal* (to appear, 2012).
152. Mikyška, J., and Firoozabadi, A.: “Investigation of Mixture Stability at Given Volume, Temperature, and Number of Moles,” *Fluid Phase Equilibria* (to appear, 2012).
153. Li, Z. and Firoozabadi, A.: “General Strategy for Stability Testing and Phase-split Calculation in Two and Three Phases,” *SPE Journal* (to appear 2012).
154. Moortgat, J., Firoozabadi, A., Li, Z. and Esposito, R.: “Effects of Gravity, Diffusion and Wettability on CO<sub>2</sub> Injection in Experimental Core-flooding and Three-Phase Compositional Modeling,” *SPE Journal* (to appear, 2012).
155. Sun, M., Y. Wang , and Firoozabadi, A.: “Effective Alcohol Cosurfactants in Hydrate Anti-agglomeration,” *Langmuir* (revision submitted)
156. Moortgat, J., Li, Z. and Firoozabadi, A.: “Three-Phase Compositional Modeling of CO<sub>2</sub> Injection by Higher-Order Finite Element Methods with PR and CPA Equations of State,” *Water Resources Research* (revision to be submitted).

## Recent Keynote Speeches, Invited Talks, and Graduate Seminars Since 2006

### 2006

1. "Measurement of Molecular and Thermal Diffusion Coefficients in Multicomponent Mixtures," Layman Handy Colloquium Series, Department of Chemical Engineering and Materials Science, University of Southern California, Los Angeles, February 9.
2. (a) "Wettability Alteration to Intermediate Gas Wetting," (b) "Numerical Simulation of Fractured Reservoirs," Petroleum Development Oman, Oman, February 20.
3. "Wettability Alteration to Intermediate Gas Wetting," 3M Corporation, St. Paul, MN, April 5.
4. "Numerical Simulation of Fractured Reservoirs Using the Discontinuous Galerkin – Mixed Methods and Proposal for Improved Recovery in Mexican Fractured Reservoirs," Pemex, Ciudad Del Carmen, Mexico, May 18.
5. "Numerical Modeling of Diffusion in Fractured Reservoirs," Invited Talk, SPE Forum on Naturally Fractured Reservoirs, Denver, CO, June 20.
6. "Thermodynamics of Hydrocarbon Reservoirs," Intensive Course, Palo Alto, Aug. 7-10. 14 participants.
7. "Thermodynamics of Hydrocarbon Reservoirs," Intensive Course, Chevron Technology Center, San Ramon, CA, Aug. 21-24, 14 participants.
8. "Gas Condensate Reservoirs," Intensive Course, Society of Petroleum Engineers, Houston, TX, 24 participants.
9. "Numerical Simulation of Multicomponent-Multiphase Flow in Fractured Media and Need for New Modeling," Petroleum Engineering Department, Texas A&M, College Station, TX, Aug. 29.
10. "Numerical Simulation in Fractured Media Incorporating the Concept of Crossflow Equilibrium" and "Well Deliverability Increase in Gas Condensate Reservoirs by Wettability Alteration," Total, Pau, France, Nov. 20.
11. "Numerical Simulation in Fractured Media Incorporating the Concept of Crossflow Equilibrium" and "Convection and Diffusion in Hydrocarbon Reservoirs," BP, Sunbury on Thames, UK, Nov. 21.
12. "Numerical Simulation in Fractured Media Incorporating the Concept of Crossflow Equilibrium" and "Well Deliverability Increase in Gas Condensate Reservoirs through Wettability Alteration," Maersk Oil and Gas, Copenhagen, Denmark, Nov. 22.
13. "Numerical Simulation of Gas and Water Injection in Fractures by Discontinuous Galerkin and Mixed Methods" and "Wettability Alteration to Intermediate Gas Wetting," ConocoPhillips, Houston, TX, Dec. 11.
14. "Diffusion in Multicomponent Mixtures and its Effect on Oil Recovery in Fractured Reservoirs," IMP, Mexico City, Dec. 12.

### 2007

1. "CO<sub>2</sub> Injection in Fractured Reservoirs," Occidental Oil and Gas, Elk Hills, CA, January 15.
2. "Thermodynamics and Mathematics of Species Transport in Permeable Media and Conduits," Yale University, Mechanical Engineering Department, New Haven, CT, March 30.
3. Invited External Examiner for PhD Thesis of Reza Darvish on "Physical Effects Controlling Mass Transfer in Matrix-Fracture System during CO<sub>2</sub> Injection Into Chalk Fractured Reservoirs," Department of Petroleum Engineering and Geophysics, Norwegian University of Science and Technology, Trondheim, Norway, April 16.
4. "Kinetics and Anti-Agglomeration in Gas Hydrates," Bergen University, Department of Chemistry, Bergen, Norway, April 17.
5. Invited External Examiner for PhD Thesis of Shan Pan on "Theoretical and Numerical Study of Thermodiffusion and Thermosolutal Convection," University of Toronto, Department of Chemical Engineering and Chemistry, August 10.

6. "Multicomponent Diffusion from Irreversible Thermodynamics," Rice University, Houston, TX, May 31.
7. "CO<sub>2</sub> Injection in Fractured Reservoirs," Mexican Petroleum Institute, Mexican Delegation Visit, Mexico City, Mexico, August 30.
8. "Hydrocarbon Energy Production and Environmental Stewardship," Yale University, September 12.
9. "CO<sub>2</sub> Injection in Fractured Reservoirs: Numerical Modeling and the Effect of Diffusion," ConocoPhillips, Bartlesville, OK, October 2.
10. "Numerical Modeling of Complex Reservoirs and the Use of High-Order Methods," Schlumberger Research, Cambridge, MA, October 5.
11. "Numerical Simulation of Fractured Petroleum Reservoirs for Improved Recovery," Occidental Oil and Gas, Houston, TX, October 11.
12. Invited External Examiner for PhD Thesis of Hassan Karimaie on "Aspects of Water and Gas Injection in Fractured Reservoirs," Norwegian University of Science and Technology, Department of Petroleum Engineering and Geophysics, Trondheim, Norway, December 17.
13. "Numerical Simulation of Complex Reservoir Problems for CO<sub>2</sub> Injection," Delft University of Technology, Department of Civil Engineering, Delft, Holland, December 18.

## **2008**

1. "Diffusion Aspects of CO<sub>2</sub> Injection into Ekofisk Field" ConocoPhillips, Technology Research Center, Bartlesville, OK, March 3.
2. "Numerical Simulation of Gas and Water Injection in Complex Reservoirs Using Higher-order Methods," BP, Houston, May 20.
3. "Thermal diffusion in multicomponent mixtures: theoretical modeling and experiments," Invited Plenary Talk, 8th International Meeting on Thermodiffusion, Bonn, Germany, June 9-13.
4. "Study of CO<sub>2</sub> Injection in Brazilian Light and Heavy Oil Reservoirs," Petrobras, Rio de Janeiro, Brazil, June 26.
5. "CO<sub>2</sub> Injection in Hydrocarbon Reservoirs," Mechanical Engineering Department, Catholic University, Rio de Janeiro, Brazil, June 26.
6. "Interfacial composition at the Interface between two non-equilibrium phases," Chemical Engineering Department, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil, June 27
7. "Modeling of non-equilibrium effects in CO<sub>2</sub>-water and CO<sub>2</sub>-hydrocarbons," Occidental Oil and Gas, Elk Hills, CA, July 7.
8. "Hydrocarbons Energy Production, and Environmental Stewardship," Shell Research Center, Rijsvijk, Holland, Nov. 24.
9. "Water-Hydrocarbons and Asphaltene Modeling Using Association and Physical Interactions" BP Research Center, Sunbury on Thames, UK, Nov. 27
10. "Unusual Issues of CO<sub>2</sub>-water phase behavior and CO<sub>2</sub> oil-displacement in improved oil recovery and sequestration," Total, Paris, Nov. 28.

## **2009**

1. "CO<sub>2</sub> Injection in Complex Subsurface Formations for IOR and Sequestration and Features in Thermodynamics and Fluid Mechanics," Keynote Talk, 4<sup>th</sup> International Conference on Energy and Applications, Abu Dhabi, Jan. 12-14.
2. "CO<sub>2</sub> Injection in Complex Subsurface Formations," Maersk Oil SA, Doha, Qatar, Jan. 17.
3. "CO<sub>2</sub> Injection in Complex Subsurface Formations for IOR and Sequestration and Features in Thermodynamics and Fluid Mechanics," Invited Talk, Chevron, San Ramon, CA, April 13.

4. "CO<sub>2</sub> Injection in Hydrocarbon Reservoirs: Phase Behavior, Diffusion, and Density-Driven Mixing," ConocoPhillips Company, Bartlesville, OK, April 23.
5. "CO<sub>2</sub> Injection in Hydrocarbon Reservoirs and the Effect of Density-Driven Mixing and Diffusion," Pemex, Ciudad del Carmen, Mexico, May 18.
6. Invited External Examiner for PhD Thesis of Rouhollah Farajzadeh on "Enhanced Transport Phenomena in CO<sub>2</sub> Sequestration and CO<sub>2</sub> EOR," Department of Civil Engineering, Delft University of Technology, Delft, Netherlands, June 2.
7. (a) "Asphaltene Precipitation in Petroleum Reservoirs," (b) "Alteration of Wettability by Surfactant Treatment," OMV Austria Exploration & Production GmbH, Vienna, Austria, June 4.
8. (a) "Theoretical Modeling of Diffusion Cell Experiments," (b) "Alteration of Wettability of Porous Media to Gas-Wetting," TOTAL SA, Paris, France, June 5.
9. "Effectiveness of Rhamnolipid Surfactant on Hydrate Anti-agglomeration," StatoilHydro ASA, Bergen, Norway, June 9.
10. "Effect of Diffusion and Density-Driven Mixing in CO<sub>2</sub> Injection," ConocoPhillips Company, Stavanger, Norway, June 10.
11. "CO<sub>2</sub> Injection in Subsurface Formations and Features in Thermodynamics, Fluid mechanics and Numerical Modeling," Faculty of Engineering, Peking University, Peking, China, June 15.
12. "CO<sub>2</sub> Injection in Subsurface Formations and Features in Thermodynamics, Fluid mechanics and Numerical Modeling," Chemical Engineering Department, Tsinghua University, Peking, China, June 16.
13. "Equilibrium and Non-Equilibrium Thermodynamics of Hydrocarbon Reservoirs," Intensive Advance Course, Japan Exploration Co. Ltd. (JAPEx), Tokyo, Japan, June 17-19.
14. "Carbon Management Canada". Invited Expert Plan, Networks of Centers of Excellence – Canada, Ottawa, Canada, August 31 - Sep. 2.
15. "Carbon Dioxide Injection in Complex Subsurface Formations and Features of the Process in Thermodynamics and Fluid Mechanics," Graduate Seminar, Department of Chemical Engineering, University of Waterloo, Waterloo, Ontario, Canada, Nov. 5.
16. "CO<sub>2</sub> Injection in Complex Subsurface Formations and Issues in Thermodynamics and Fluid Mechanics," Invited talk, AIChE Annual Meeting, Nashville, TN, Nov. 8-13.
17. "Framework for Compositional Modeling in Multiphase Flow: Fluid Flow by Finite Elements and Thermodynamic Stability Considerations," The Center for Subsurface Modeling, University of Texas, Austin, TX, Oct. 15.
18. "Theoretical and Numerical Modeling Aspects of CO<sub>2</sub> Injection in the Subsurface," Graduate Seminar, Department of Mechanical and Aerospace Engineering, Rutgers University, Piscataway, NJ, Dec. 9.
19. "Theoretical and Numerical Modeling of CO<sub>2</sub> Injection in the Subsurface," Graduate Seminar, King Abdullah University of Science and Technology (KAUST), Saudi Arabia, January 14.
20. "Framework for simulation of CO<sub>2</sub> and other gas injection schemes in the subsurface," Saudi Aramco (Aramco), Dhahran, Saudi Arabia, Jan. 18.
21. "Gas Condensate Reservoirs Recovery and Productivity," Kuwait Oil Company (KOC), Ahmadiyah, Kuwait, Jan. 22.

## **2010**

1. "Delayed Sedimentation in Asphaltenes by Size Reduction to nano-particles using surfactants" Precipitation Modeling," and other talks at Ecopetrol, Bogota, Columbia, Jan. 18.
2. "Numerical Simulation of Complex Hydrocarbon Reservoirs by Finite Element Methods," Invited Plenary Talk, 5th International Congress on Numerical Methods in Engineering, Guanajuato, Mexico, February 3-5.
3. Invited External Examiner for PhD Thesis of Benjamin Pierre "Pressure Waves in Pipelines and Impulse Pumping Physical Principles, Model Development and Numerical Simulation" Norwegian University of Science and Technology, Department of Petroleum Engineering and Geophysics, Trondheim, Norway, February 19.

4. "Compositional Modeling in Three-Phase Flow Using Higher Order Methods," ExxonMobil Production Research Company, Houston, TX, February 25
5. "CO<sub>2</sub> Sequestration in the Subsurface," Yale Climate and Energy Institute, Yale University, New Haven, April 19.
6. "Modeling of CO<sub>2</sub> Injection in the Tor Fractured Reservoir," Ekofisk Partners Meeting, Bartelsville, OK, February 21-23.
7. "Modeling of CO<sub>2</sub> Injection in Water-Flooded Fractured Reservoirs" Maersk Oil and Gas, Copenhagen Denmark, June 8.
8. "CO<sub>2</sub> Injection in the Ekofisk and Issues," ConocoPhillips Norway, Stavanger, Norway, June 9-11.
9. Invited External Examiner for PhD Thesis of Hamidreza Salimi "Physical Aspects of Upscaling of Fractured Reservoirs and Improved Oil Recovery Predictions" Department of Civil Engineering, Delft University of Technology, Delft, Netherlands, June 14.
10. "Thermodynamic Stability and Phase-Split Computations in Three-Phase," Schlumberger, Abington Technology Center, June 15.
11. "Physics and Modeling of CO<sub>2</sub> Injection in Fractured Media and Surprises," Gordon Research Conference , " July 12-16., Bates College, Lewiston, ME, July 12-16.
12. "CO<sub>2</sub> Injection Pilot in the Mexican Fractured Reservoirs," Pemex, Ciudad del Carmen, Mexico, Aug. 17.
13. Invited External Examiner for PhD Thesis of Radek Fucik "Advanced Numerical Methods for Modeling Two-Phase Flow in Heterogeneous Porous Media," Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Prague, Nov. 12.

## **2011**

1. "Higher-order Numerical Modeling of Multiphase Flow in Unfractured and in Fractured Media," Institute of Hydraulic Engineering University of Stuttgart, Stuttgart, Germany, Jan. 31.
2. "Higher-order Modeling of CO<sub>2</sub> Subsurface Sequestration Coupled with Cross Association of CO<sub>2</sub> and H<sub>2</sub>O Molecules," Department of Earth Sciences, Imperial College London, February 1.
3. "CO<sub>2</sub> Injection in the Subsurface and Aspects from Thermodynamics, Fluid Dynamics and Mathematical Modeling," Department of Chemical Engineering, Princeton University, Princeton, NJ., February 3.
4. "Thermodynamic Stability Testing and Phase-split Calculation in Two- and Three-Phase," Saudi Aramco, Dhahran, March 14.
5. "Water, CO<sub>2</sub>, and N<sub>2</sub> Injection in Near-critical Fractured Reservoirs," Joint Meeting of Kuwait Oil Company, Schlumberger and Shell, Kuwait City, Kuwait, March 16.
6. a) "Nano-particle Stabilization of Asphaltenes and Hydrates," b) "Two- and Three-phase Compositional Modeling of CO<sub>2</sub> Injection with CPA Equation of State," ADCO, Abu Dhabi, March 17.
7. "Carbon Dioxide Injection in the Subsurface and Considerations in Thermodynamics, Fluid Mechanics, and Numerical Modeling," Clarkson University, Potsdam, New York, March 29.
8. "Two- and Three-phase Compositional Modeling of CO<sub>2</sub> Injection with CPA Equations of State," ConocoPhillips, Houston, TX, April 6.
9. "Species Distribution and Recovery Performance from Fluid Injection in a Giant Field," Petrobras, Rio de Janeiro, April 15.
10. "CO<sub>2</sub> Subsurface Injection and Related Issues in Thermodynamics, Fluid Mechanics, and Numerical Modeling," School of Engineering and Applied Sciences, Harvard University, May 3.
11. "Asphaltene Stabilization in Petroleum Fluids and Precipitation Modeling," BP, Houston, TX, November 4.
12. "Nano-particles in Hydrocarbon Energy Production," University of California-Riverside, Environmental Sciences Department, Riverside, CA, November 21.
13. "Nano-particles in Hydrocarbon Energy Production," Illinois Institute of Technology, Department of Chemical and Biological Engineering, Chicago, IL, November 30.

14. "Carbon Dioxide Injection in the Subsurface and Considerations in Thermodynamics, Fluid Mechanics, and Numerical Modeling," University of Oklahoma, Department of Petroleum Engineering, Norman, OK, December 2.
15. "Nano-particles in hydrocarbon energy production", "CO<sub>2</sub> injection in heterogeneous and fractured media", Total Research Center Pau, France, December 5.
16. "CO<sub>2</sub> Injection in Complex Reservoirs for Improved Oil Recovery," AGR, Oslo, Norway, December 6.

## **2012**

1. "Lectures in Thermodynamics and in Multiphase Flow in Fractured Permeable Media", Mexican Petroleum Institute, Mexico City, Mexico, January 12-13 (about 25 attendee from IMP scientists).
2. "Nano-particles in Hydrocarbon Energy Production," King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia, March 3.
3. "Electrostatic Stabilization of Asphaltene Colloidal Particles through Effective Dissolution by Surfactants in Petroleum Fluids," ADCO, Abu Dhabi, March 5.
4. "CO<sub>2</sub> Effectiveness in Improved Oil Recovery in Fractured media," ConocoPhillips, Houston, April 19.
5. "Carbon Dioxide Injection in the Subsurface and Considerations in Physics and Numerical Modeling " Opening talk, Acid Gas International Symposium, AGIS2012, Banff, Canada, May 31- June 1.
6. "Framework to Study Complexities from the Combined Effects of Thermal, Pressure, and Fickian Diffusions in Multi-components," Keynote lecture, Tenth International Thermodiffusion Conference (IMT'10), Brussels, Belgium, June 4-8.