

SMU Department of Mechanical Engineering **SEMINAR**

“Modeling Gas Transport in Shale Reservoirs and
Measuring Nano-Darcy Shale Permeability”



Professor Faruk Civan

Mewbourne School of Petroleum and Geological Engineering
University of Oklahoma, Norman, Oklahoma

Friday, February 14, 2014

2:00 p.m. – 3:00 p.m.

Location: Huitt-Zollars Pavilion

Abstract: Rigorous shale reservoir analysis, relevant pore geometry and physics of fluids, proper formulation of fluid transport, and manipulation of existing simulators are discussed. Importance of adsorbed-layer, fluid-behavior modification, and non-Darcy behavior is described for transport of fluids through extremely-low permeability shale sediments, acting both as source and storage of oil and gas. Deviations from Darcian flow under low and high pressure conditions; effects of hydraulic, formation, and completion damages; pore-throat pressure pulsation, pore-surface capture and mobilization of emulsified bubbles in water and droplets in gas; non-equilibrium phase relaxation; stress-sensitivity to drawdown and incomplete capillary fluid entrapment of natural fractures; hybrid-relative permeability and non-equilibrium capillary pressure; kerogen distribution and connectivity; upscaling organic/inorganic heterogeneity by single and dual media treatments with commercial simulators are explained. Nano- Darcy transport is modeled by series of low and high-permeability capillary tubes, leakytanks, and continuum approaches, and illustrated by examples for measurement of core and crushed-shale permeability using the pressure-pulsing technique and for simulation of hydraulically fractured reservoirs.

Bio: FARUK CIVAN is the Martin G. Miller Chair Professor in the Mewbourne School of Petroleum and Geological Engineering at the Univ. of Oklahoma. He formerly held the Brian and Sandra O'Brien Presidential and Alumni Chair Professorships. Previously, he worked at the Technical Univ. of Istanbul, Turkey. His principal research interests include fossil and sustainable energy resources development; carbon sequestration; unconventional gas and condensate reservoirs; reservoir and well/pipeline hydraulics and flow assurance; oil and gas processing, transportation, and storage; multiphase transport phenomena in porous media; environmental pollution assessment, prevention, and control; and mathematical modeling and simulation. He is the author of two books: *Porous Media Transport Phenomena* (John Wiley & Sons, 2011), and *Reservoir Formation Damage: Fundamentals, Modeling, Assessment, and Mitigation* (Elsevier, 2007). He has published more than 330 technical articles in journals, edited books, handbooks, encyclopedias, and conference proceedings, and presented worldwide more than 125 invited seminars and/or lectures at various technical meetings, companies, and universities. He holds an advanced degree of engineering from the Technical Univ. of Istanbul, Turkey, an MS from the Univ. of Texas at Austin, and a PhD from the Univ. of Oklahoma, all in chemical engineering. He is a member of AIChE and the Society of Petroleum Engineers (SPE), and a member of the editorial boards of several journals. He has served on numerous AIChE and SPE technical committees. Civan has received 20 honors and awards, including five distinguished lectureship awards and the 2003 SPE Distinguished Achievement Award for Petroleum Engineering Faculty. Faruk Civan may be contacted at the Mewbourne School of Petroleum and Geological Engineering, The University of Oklahoma, 100 East Boyd, SEC Room 1210, Norman, Oklahoma 73019, U.S.A. Telephone: (405) 325-6778; FAX: (405) 325-7477; E-mail: fcivan@ou.edu.

SMU Department of Mechanical Engineering **SEMINAR**

“An Exploratory Analysis of the Challenges in
Describing Fluid Behavior in Shales”

Professor Deepak Devegowda

Mewbourne School of Petroleum and Geological Engineering
University of Oklahoma, Norman, Oklahoma

Friday, February 14, 2014

3:00 p.m. – 4:00 p.m.

Location: Huitt-Zollars Pavilion

Abstract: As exploration and development activities expand to target gas condensate and liquid production in shale plays, the underlying mechanisms controlling liquids transport and storage in tight nanoporous media merit further attention. Shale formations are characterized by nanometer-scale pore throats on the order of 1-100 nm while the molecule sizes tend to vary from a minimum of 0.4 nm for methane to somewhat larger values for higher carbon number hydrocarbons. The effects of pore wall proximity and multi-component adsorption with only a few molecules occupying the nano-scale pores necessitates an understanding of how fluid storage, transport properties such as phase relative permeabilities and fluid properties such as phase behavior, viscosity and interfacial tension deviate from their corresponding bulk fluid values. These alterations have been shown to cause produced stream compositions and gas-oil ratios to be very different than what would be expected for a conventional reservoir containing the same fluid mix.

It has been well known to geophysicists and petrophysicists that the freezing point of clay-bound water in shale in the Arctic permafrost is suppressed and modifications to hydrocarbon fluid properties are analogous to this; but the extension to multi-component hydrocarbon mixtures in complex pore networks is not so straightforward. There are several studies documenting alternations in fluid behavior in nanopores with simplified wall structures, wall potentials, and single pore sizes but a rigorous study related to hydrocarbon fluids behavior in nanoporous shales is still lacking.

This work presents an overview of the work being performed at the University of Oklahoma to understand fluid behavior in these shale nanopores. The oil and gas industry has only begun to study the petrophysical and mechanical properties of shales and this talk will explore some of the challenges associated with quantifying fluid behavior and fluid-rock interactions in organic-rich shales.

Bio: Deepak Devegowda is an Assistant Professor in the Mewbourne School of Petroleum and Geological Engineering at the University of Oklahoma. His research interests lie in the areas of high resolution reservoir description and modeling and management of unconventional oil and gas reservoirs. He is the principal investigator on a US\$1.5 million research grant to develop novel shale simulation tools and also heads a consortium of 10 companies involved in shale development activities. He is also part of two industry consortia focusing on the development of tight oil and gas resources in the US. He is also a Technical Committee Member for the SPE Unconventional Resources Conference held every April in the US. He holds a Bachelor's degree in Electrical Engineering from the Indian Institute of Technology, Madras, India. He earned his Ph.D. degree and M.S degree, both in Petroleum Engineering at Texas A&M University.