RICE

Consortium for Processes in Porous Media

26th Annual Meeting

Rice University, Houston, TX

Dec 8th, 2022

Rice University Campus Map

Parking: North Annex

Enter with your own credit card; exist with parking pass (provided by the consortium)

Meeting Venue:

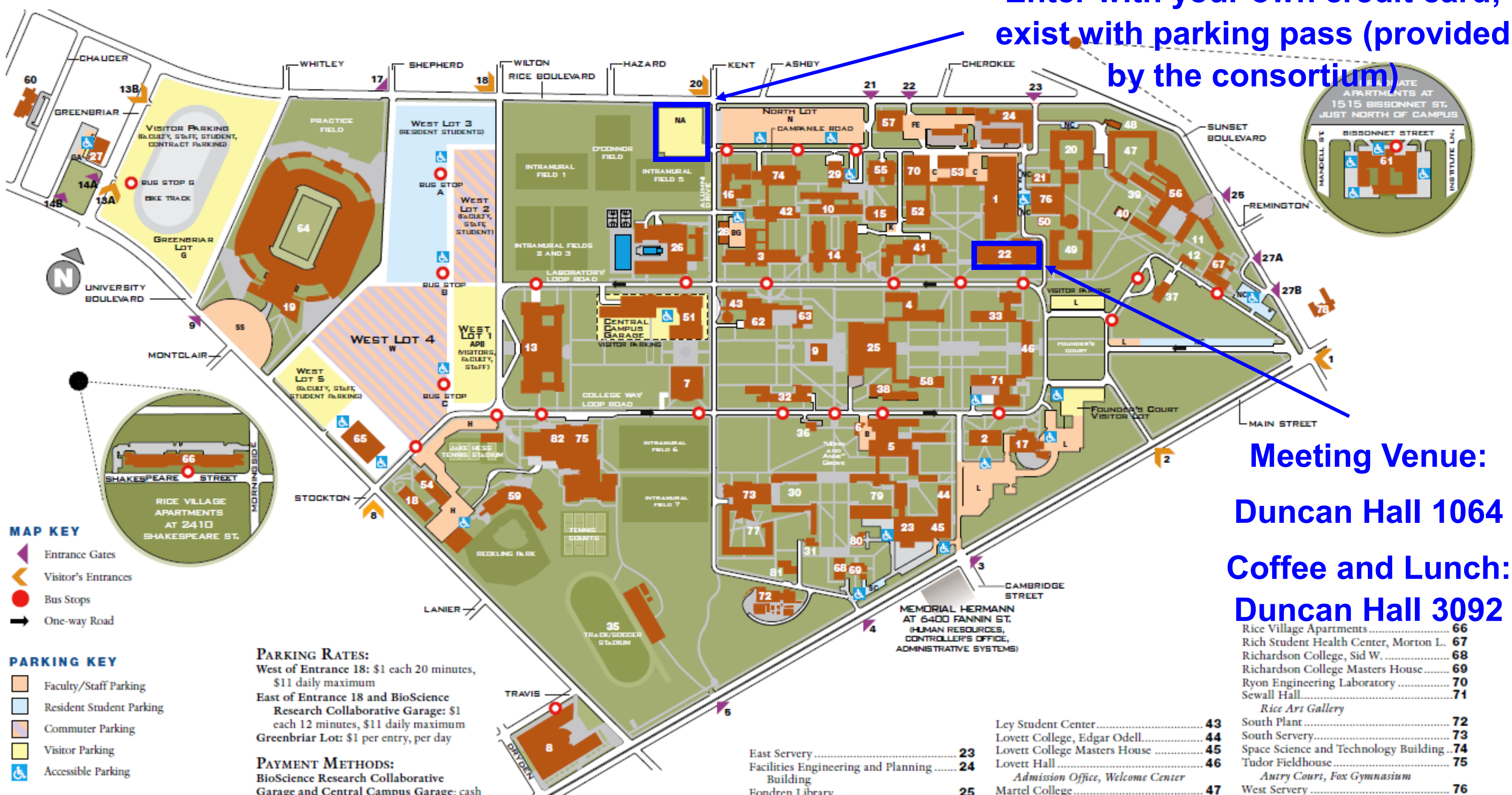
Duncan Hall 1064

Coffee and Lunch:

Duncan Hall 3092

RICE UNIVERSITY CAMPUS MAP

6/2011



MAP KEY

- Entrance Gates
- Visitor's Entrances
- Bus Stops
- One-way Road

PARKING KEY

- Faculty/Staff Parking
- Resident Student Parking
- Commuter Parking
- Visitor Parking
- Accessible Parking

PARKING LOTS:

- **APB** Alice Pratt Brown Hall Lot
- **B** Baker College–Housing & Dining Lot
- **BG** Biology–Geology Lot
- **BRC** BioScience Research Collaborative Garage
- **C** Campanile Lot
- **CG** Central Campus Garage
- **FE** Facilities, Engineering and Planning Lot
- **G** Greenbriar Lot
- **GA** Greenbriar Annex
- **H** Hess Court Lot
- **K** Keck Lot
- **L** Lovett Lot
- **N** North Lot
- **NA** North Annex Lot
- **NC** North Colleges Residents Lot
- **SC** South Colleges Residents Lot
- **SS** South Stadium Lot
- **W** West Lot

PARKING RATES:
West of Entrance 18: $1 each 20 minutes, $11 daily maximum
East of Entrance 18 and BioScience Research Collaborative Garage: $1 each 12 minutes, $11 daily maximum
Greenbriar Lot: $1 per entry, per day

PAYMENT METHODS:
BioScience Research Collaborative Garage and Central Campus Garage: cash or credit card
Greenbriar Lot, Founder's Court, North and West Lots Visitor Section: credit card

BUILDINGS

Abercrombie Engineering Laboratory 1
Allen Business Center 2
President's Office
Anderson Biological Laboratories, M.D. 3
Anderson Hall, M.D. 4
Dean of Architecture
Baker College 5
Baker College Masters House 6
Baker Hall, James A. III 7
Dean of Social Sciences, James A. Baker III Institute for Public Policy
BioScience Research Collaborative 8
Brochstein Pavilion, Raymond and Susan ..9
Brockman Hall for Physics 10
Brown College, Margarett Root 11
Brown College Masters House 12
Brown Hall, Alice Pratt 13
Dean of Shepherd School of Music
Brown Hall, George R. 14
Dean of Wiess School of Natural Sciences
Brown Hall for Mathematical Sciences, Herman 15
Butcher Hall, Dell 16
Cohen House, Robert and Agnes 17
Continuing Studies, Martel Center for ... 18
Dean of Susanne M. Glasscock School of Continuing Studies
Cox Fitness Center, John L. 19
Duncan College 20
Duncan College Masters House 21
Duncan Hall, Anne and Charles 22
Dean of George R. Brown School of Engineering
East Servery 23
Facilities Engineering and Planning Building 24
Fondren Library 25
Gibbs Recreation and Wellness Center, Barbara and David 26
Greenbriar Building 27
Greenhouse 28
Hamman Hall 29
Hanszen College 30
Hanszen College Masters House 31
Herring Hall, Robert R. 32
Herzstein Hall 33
Hess Tennis Stadium, Jake 34
Holloway Field 35
Wendel D. Ley Track
Housing and Dining 36
Huff House, Peter and Nancy 37
Alumni Affairs
Humanities Building 38
Dean of Humanities
Jones College, Mary Gibbs 39
Jones College Masters House 40
Keck Hall 41
Keith-Wiess Geological Laboratories 42
Ley Student Center 43
Lovett College, Edgar Odell 44
Lovett College Masters House 45
Lovett Hall 46
Admission Office, Welcome Center
Martel College 47
Martel College Masters House 48
McMurtry College, Burton and Deedee . 49
McMurtry College Masters House 50
McNair Hall, Janice and Robert 51
Dean of Jesse H. Jones Graduate School of Business
Mechanical Engineering Building 52
Mechanical Laboratory 53
Media Center 54
Mudd Computer Science Building 55
North Servery 56
Oshman Engineering Design Kitchen 57
Rayzor Hall 58
Reckling Park at Cameron Field 59
Rice Children's Campus 60
Rice Graduate Apartments 61
Rice Memorial Center 62
Campus Bookstore
Rice Memorial Chapel 63
Rice Stadium 64
Rice University Police Department 65
Rice Village Apartments 66
Rich Student Health Center, Morton L. 67
Richardson College, Sid W. 68
Richardson College Masters House 69
Ryon Engineering Laboratory 70
Sewall Hall 71
Rice Art Gallery
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South Servery 73
Space Science and Technology Building .. 74
Tudor Fieldhouse 75
Autry Court, Fox Gymnasium
West Servery 76
Wiess College 77
Wiess President's House 78
Will Rice College 79
Will Rice College Masters House 80
Wilson House 81
Wiess College Masters
Youngkin Center 82

ACADEMIC SCHOOLS

Architecture, School of 4
Business, Jesse H. Jones Graduate School of 51
Continuing Studies, Susanne M. Glasscock School of 18
Engineering, George R. Brown School of 22
Humanities, School of 38
Music, The Shepherd School of 13
Natural Sciences, Wiess School of 14
Social Sciences, School of 7

Meeting Agenda: Morning Session

Thursday, Dec 8th

NMR & Unconventional

8:15 am — 8:30 am	Coffee	
8:30 am — 8:45 am	Opening Speech	Dr. George Hirasaki
8:45 am — 9:30 am	Overview of NMR core-analysis projects	Dr. Philip Singer
9:30 am — 10:00 am	Permeability Anisotropy Estimation in Organic-Rich Chalk by NMR Restricted Diffusion	Dr. Xinglin Wang
10:00 am — 10:30 am	Separation of solid and liquid components in organic-rich chalks using NMR relaxation	Mr. Yunke Liu
10:30 am — 10:45 am	Coffee Break	
10:45 am — 11:15 am	Contrasting NMR relaxation at high viscosity probed by atomistic simulations of glycerol and polymer (recorded)	Dr. Arjun Parambathu
11:15 am — 11:45 am	Formation Evaluation in the Energy Transition	Dr. George Hirasaki
11:45 am — 12:45 pm	Lunch	

Meeting Agenda: Afternoon Session

Thursday, Dec 8th

12:45 pm—1:15 pm	How Foam Develops Apparent Viscosity in CO_2 EOR	Dr. George Hirasaki
1:15 pm — 1:45 pm	Characterization of N_2 Foam Flow with in-situ Capillary Pressure Measurements in a High-Permeability Homogeneous Sandpack	Mr. Chutian Bai
1:45 pm — 2:15 pm	Qualitatively Comparing the Effect of Gas Types on Foam Texture and Foam Dynamics	Ms. Mavis Wang
2:15 pm — 2:45 pm	Inhibiting Asphaltene Deposition Using Polymer Functionalized Nanoparticle (recorded)	Ms. Thao Vy Nguyen
2:45 pm — 3:15 pm	Suggestions from Consortium	Dr. George Hirasaki

Enhanced Oil Recovery

General Remarks

Thursday, Dec 8th: 8:30 am — 8:45 am

Opening Speech

Dr. George J. Hirasaki

A.J. Hartsook Emeritus Professor in Chemical Engineering (gjh@rice.edu)

Abstract

Welcome to the 26th annual meeting of the Consortium on Processes in Porous Media. We had our first meeting in 1996. The goal of this consortium is to engage in collaborative research to advance the fundamental understanding of porous media processes. Our core research areas include the study of surfactant, CO_2 foam Enhanced Oil Recovery (EOR) processes, and NMR & molecular simulation studies of unconventional formations. As the director of this research consortium, I thank you for your support of our research and welcome you to potential opportunities for collaboration and participation.

Notes

Presentations

Thursday, Dec 8th: 8:45 am — 9:30 am

Overview of NMR core-analysis projects

Dr. Philip M. Singer

Assistant Research Professor (ps41@rice.edu)

Abstract

The current trend in ^{1}H NMR core-analysis is to go to higher frequencies, i.e., above 2 MHz. In this presentation, we highlight some recent examples of 20 MHz T_1-T_2 data in low-permeability organic-rich chalk. The data demonstrate how 20 MHz instruments (with shorter dead times) can d tect solid-like signals including kerogen, bitumen, and clay hydroxyls. Furthermore, 20 MHz provides better T_1/T_2 contrast for determining hydrocarbon saturation. Concurrently, the data also imply that 2 MHz core-analysis is required for calibrating the interpretation of NMR logs.

We then use the frequency dependence, temperature dependence, EPR (electron paramagnetic resonance), and MD (molecular dynamics) simulations to show that the dominant NMR relaxation mechanism for viscous fluids and fluids under nano-confinement is ^{1}H-^{1}H dipole-dipole relaxation rather than paramagnetism.

We conclude that the best approach in NMR core-analysis is the synergy of 2 MHz and 20 MHz, and we provide some suggestions for best practices.

Notes

Presentations

Thursday, Dec 8th: 9:30 am — 10:00 am

Permeability Anisotropy Estimation in Organic-Rich Chalk by NMR Restricted Diffusion

Dr. Xinglin Wang
(xw51@rice.edu)

Abstract

We present a new method for studying permeability anisotropy using NMR restricted diffusion measurements. The NMR restricted diffusion measurements were made with a 2.3 MHz NMR core analyzer core plugs drilled parallel (horizontal) and perpendicular (vertical) to the bedding plane. The cores at connate water saturation were then saturated with methane at 1, 200 psi and then saturated with decane for NMR measurements. Pore size and tortuosity were estimated based on the NMR-restricted diffusion versus diffusion length data, and then used in a modified Carman-Kozeny model to predict the permeability anisotropy.

The permeabilities, computed from a modified Carman-Kozeny model, shows that the tortuosity is the main factor in the anisotropy of the measured core permeabilities. The diffusive tortuosity is much greater in the vertical direction than the horizontal direction due to the additional diffusional restriction from the depositional laminations. We find that the L_D at which the vertical core reaches its tortuosity limit is significantly shorter than in the horizontal direction.

We propose a new method to measure the permeability anisotropy using NMR restricted diffusion and Carman-Kozeny model. This method can reduce the diffusive coupling using hydrocarbon saturation on cores with connate water and make a more accurate permeability estimation.

Notes

Presentations

Thursday, Dec 8th: 10:00 am — 10:30 am

Separation of Solid and Liquid Components in Organic-Rich Chalks

Mr. Yunke Liu

PhD Graduate Student, 4th Year (yl179@rice.edu)

Abstract

Currently there is great interest in interpreting the ^1H NMR T_2 relaxation (i.e., transverse relaxation) of porous geological media containing both liquid-like and solid-like signals. This has an impact on the interpretation of commercial NMR core and log analysis of organic-rich shales, such as shale oil and shale gas, where T_1-T_2 relaxation maps are routinely used to identify sweet spots and producibility of the hydrocarbon reservoir.

We report a novel method to separate liquid-like components with an exponential decay (T_{2e}) in transverse magnetization from solid-like components with a Gaussian decay (T_{2G}). The method uses novel pulse sequences together with a 20 MHz ^1H NMR relaxometer optimized for reservoir core plugs. The method is applied to obtain 2D T_1-T_2 maps in organic-rich chalks saturated with water or heptane, as well as bitumen-extracted samples. The maps clearly distinguish liquid-like signals (including micro/meso-macro pore fluids, heptane dissolved in bitumen, and clay-bound water) from solid-like signals (including kerogen, bitumen, and clay hydroxyls) in the organic-rich chalks.

Notes

Presentations

Thursday, Dec 8th: 10:45 am — 11:15 am

Contrasting NMR relaxation at high viscosity probed by atomistic simulations of glycerol and polymer (recorded)

Dr. Arjun Valiya Parambathu

Postdoctoral Researcher at the University of Delaware (arjunvp@udel.edu)

Abstract

The traditional Bloembergen, Purcell, and Pound (BPP) model is the cornerstone in interpreting NMR relaxation times of fluids. However, measurements of NMR relaxation in crude oil and polymer-alkane mixtures showed significant deviation from BPP theory at high viscosity. Our recent molecular simulation results show this is a consequence of assumptions made in BPP theory. But, it is intriguing that BPP theory was compared to glycerol measurements that were a satisfactory match. In this regard, we utilize atomistic simulations to compute NMR relaxation in the two contrasting cases: glycerol and poly(isobutene). We simulated over five decades of viscosity over temperature: glycerol by varying temperature and poly (isobutene) by varying molecular weight. We find that dipole-dipole relaxation alone explains the measurements for both cases. Both cases showed significant deviation from the BPP theory for intramolecular relaxation. Rather than the mono-exponential decay of autocorrelation (assumed in BPP theory), we observe a multimodal distribution of exponential correlation times. The modes indicate that the difference in relaxation behavior is primarily due to the hydrogen bonding network in glycerol, causing the glycerol to be more rigid than poly(isobutene).

Notes

Presentations

Thursday, Dec 8th: 11:15 am — 11:45 am

Formation Evaluation in the Energy Transition

Dr. George J. Hirasaki

A.J. Hartsook Emeritus Professor in Chemical Engineering (gjh@rice.edu)

Abstract

Our society has a dual need for fossil energy but yet reduce the emission of carbon dioxide. These dual needs can be met with carbon capture, utilization, and storage (CCUS). Our industry has been practicing CO_2 EOR for over 50 years. Earlier sources of CO_2 were natural sources but now the US has pipelines and infrastructure for distributing natural and industrial CO_2 to locations where they can be utilized and/or stored. Also, NMR formation evaluation technology is being developed to quantitively measure the distribution of hydrocarbon in the organic and inorganic porosity of unconventional formations. This has promise for evaluating for CO_2 "Huff-n-Puff" EOR in unconventional formations.

Notes

Presentations

Thursday, Dec 8th: 12:45 pm — 1:15 pm

How Foam Develops Apparent Viscosity in CO_2 EOR

Dr. George J. Hirasaki

A.J. Hartsook Emeritus Professor in Chemical Engineering (gjh@rice.edu)

Abstract

CO_2 is widely used enhanced oil recovery but the low viscosity and density of CO_2 often results in poor sweep efficiency and recycling of the CO_2. This problem can be improved by in situ dispersing the CO_2 with brine to generate a foam. This process has been applied since the 1970s for steam, natural gas, and CO_2. This presentation summaries the mechanisms by which foam develops apparent viscosity, how the experiential data is fitted to empirical models, and used in reservoir simulation.

Notes

Presentations

Thursday Dec 8th: 1:15 pm — 1:45 pm

Characterization of N_2 Foam Flow with in-situ Capillary Pressure Measurements in a High-Permeability Homogeneous Sandpack: Effect of Surfactant Concentration

Conc[illegible]wrate

Mr. Chutian Bai

PhD Graduate Student, 5th Year (cb51@rice.edu)

Abstract

The capillary pressure is important in foam flow in porous media because bubbles are thought to coalesce by lamella rupture as the "limiting capillary pressure" is approached. Here, we will describe the role of surfactant concentration and flowrate on capillary pressure and apparent viscosity of a foam flowing through porous media. We designed and constructed a custom capillary-pressure probe to characterize foam flow in a 140-Darcy homogenous sandpack in our results. Foam quality scan experiments were conducted at a fixed gas velocity. The effects of surfactant concentration and flowrate on foam flow through porous media under ambient conditions were studied.

By comparing the test results collected under different flowrates and surfactant concentrations, The apparent viscosity and the capillary pressure decrease above the transition foam quality (at peak apparent viscosity). The transition foam quality increases with increasing surfactant concentration and flow rate. For the slowest velocity, a minimum surfactant concentration is required to generate strong foam. While above this minimum surfactant concentration, foam apparent viscosity is similar for different surfactant concentrations at the same velocity.

Notes

Presentations

Thursday, Dec 8th: 1:45 pm — 2:15 pm

Qualitatively Comparing the Effect of Gas Types on Foam Texture and Foam Dynamics

Ms. Yiwei (Mavis) Wang

PhD Graduate Student, 4th Year (yw87@rice.edu)

Abstract

Foam applications range from enhanced oil recovery in production wells to carbon sequestration in hydraulic fracking sites. To better predict foam flow in these natural porous media, researchers need to understand the fundamental physicochemical processes involved. Microfluidics have been proven effective in visualizing small-scale events and processes that would otherwise be difficult to observe in confined systems. In this study, we utilized a microfluidic device that mimics heterogeneous sandstone porous media to investigate the effects of gas type on foam dynamics, foam stability, foam generation, and phase mobility. Real-time imaging and image processing techniques were employed to obtain an in-depth picture of foam texture and morphology in relation to foam quality and apparent viscosity.

Notes

Presentations

Thursday, Dec 8th: 2:15 pm — 2:45 pm

Inhibiting Asphaltene Deposition Using Polymer Functionalized Nanoparticles (recorded)

Ms. Thao Vy Nguyen

PhD Graduate Student, 4th Year (tvn3@rice.edu)

Abstract

Asphaltenes constitute the heaviest and most polarizable fraction of crude oil. They are usually referred to as the "cholesterol of petroleum" because of their tendency to aggregate and precipitate, causing clogging problems not only in the wellbore and near wellbore regions, but also in pipelines and production equipment and facilities. In this study, we investigate the effectiveness of polymer functionalized nanoparticles in asphaltene mitigation. The nanoparticle has an iron (II, III) oxide core, whose surface is functionalized with AA-AMPS copolymers, which increase the nanoparticle's colloidal stability at high temperature, high salinity conditions. Approaching from a microfluidic perspective, we design a dual permeability porous micro-device, where we study asphaltene deposition of four different crude oils, with and without the presence of nanoparticles coating. Our results demonstrate that our functionalized nanoparticles are effective in mitigating asphaltene deposition in different crude oils. With further tuning of nanoparticles, mitigation effects can be improved, and application can be expanded to different surfaces (stainless steel, chromium, etc.).

Notes