KAUST workshop on Porous Media & 1st InterPore Saudi Chapter Annual Meeting

HANDBOOK

King Abdullah Univeristy of Science and Technology, Saudi Arabia

Nov.8-10, 2021

KAUST workshop on Porous Media and 1st InterPore Saudi Chapter Annual Meeting

InterPore, the International Society for Porous Media, is a non-profit independent scientific organization established in 2008. We are a young and quickly-growing community with members from academia and industry worldwide. Our general aim is to advance and disseminate knowledge for understanding, describing, and modeling natural and industrial porous media systems. The InterPore Saudi Chapter kick-off meeting was held by Zoom on May 12th, 2020, Tuesday, which gathered a number of scholars all around Saudi Arabia and Middle East. After extensive discussions with the steering committee, we decided to hold the "KAUST Workshop on Porous Media and 1st InterPore Saudi Chapter Annual Meeting" in a hybrid format on November 8-10 to facilitate collaboration among industrial and academic researchers, to play a role in setting up strategic research priorities of local agencies and to engage women's participation in science.

Date: November 8-10, 2021
November 8, 8:00 AM-12:10 PM, Building 9, Room 3131
November 9, 8:00 AM -12:10 PM, Building 9, Room 2325
November 10, 8:00 AM -12:10 PM, Building 9, Room 4223
The e-poster session: The sea-view area at the Library

Committee

- ## Advisory Committee

Chairs:

Dr. Abbas Firoozabadi, Rice University, USA

Dr. Majid Hassanizadeh, Stuttgart University, Germany

Advisory Board:

Dr. Mary Wheeler, University of Texas at Austin, USA

Dr. Zhangxing Chen, University of Calgary, Canada

Dr. Shirish Patil, King Fahd University of Petroleum and Minerals, Saudi Arabia

Dr. Ahmad AlZawawi, Ministry of Industry, and Mineral Resources, Saudi Arabia

Dr. Abdulrahman Almana, Saudi Aramco, Saudi Arabia

Dr. Yang Liu, Aramco Americas, USA

- ## Organizing Committee

Chair:

Dr. Shuyu Sun, King Abdullah University of Science and Technology, Saudi Arabia

Vice Chair:

Dr. Zhiping Lai, King Abdullah University of Science and Technology, Saudi Arabia

Dr. Bicheng Yan, King Abdullah University of Science and Technology, Saudi Arabia

Dr. Tameem Almani, Saudi Aramco, Saudi Arabia

Dr. Manal Alotibi, King Fahd University of Petroleum and Minerals, Saudi Arabia

General Secretary:

Dr. Tao Zhang, King Abdullah University of Science and Technology, Saudi Arabia

Program Committee:

Dr. Ran Tao, King Abdullah University of Science and Technology, Saudi Arabia

Dr. Yiteng Li, King Abdullah University of Science and Technology, Saudi Arabia

Mr. Ping Hu, King Abdullah University of Science and Technology, Saudi Arabia

Mr. Jie Liu, King Abdullah University of Science and Technology, Saudi Arabia

Agenda

Session 1 Mathematics in Porous media

Building 9, Room 3131, Nov. 8 moderated by Dr. Shuyu Sun

Time	Speaker	Affiliation	Topic
8:00am—8:40am			Breakfast
8:45am—8:50am	Shuyu Sun	President, InterPore Saudi Chapter	Opening
8:50am—9:00am	Tony Chan	President, King Abdullah University of Science and Technology	Welcome speech
9:00am—9:10am	Majid Hassanizadeh	Stuttgart University	Introduction of InterPore
9:10am—9:30am	Majid Hassanizadeh *	Stuttgart University	Impact of salinity contrast on the oil remobilization: micromodel experiments and modelling
9:30am—9:45am	Jun Li	King Fahd University of Petroleum and Minerals	Efficient pore-scale simulation of shale gas flows
9:45am—10:00am	Murtada Saleh Hassan Al-Jawad	King Fahd University of Petroleum and Minerals	Simulating acid wormhole utilizing the two-scale continuum model: applications, limitations, and advancement opportunities
10:00am—10:15am	Moran Wang	Tsinghua University	Effective transport properties of multiphase porous media
10:15am—10:30am	Peng Lu	Saudi Aramco	Reactive Transport Modeling Applications in Oil and Gas Industry: Insights and challenges

Session 2 Structure of Porous media
Building 9, Room 3131, Nov. 8 moderated by Dr. Zhiping Lai

Time	Speaker	Affiliation	Topic
10:30am— 10:40am			Coffee break
10:40am- 11:10am	Abbas Firoozabadi *	Rice University	Molecular structure at the bulk and interfaces in relation to hydrocarbon and renewable energy production from subsurface and environmental stewardship
11:10am- 11:25am	Theis Ivan Solling	King Fahd University of Petroleum and Minerals	Application of CT scanning in tackling challenges in upstream E&P
11:25am- 11:40am	Jack Dvorkin	King Fahd University of Petroleum and Minerals	Specific Surface Area versus Porosity from Digital Images
11:40am- 11:55am	Nouf M. Jabri	Saudi Aramco	Underground storage between potential and opportunities
11:55am- 12:10pm	Maryam Tariq Ahmed Khaleel	Khalifa University	The Design and Synthesis of Hierarchical Faujasite Zeolite

Session 3 Women in Porous Media Research

Building 9, Room 2325, Nov. 9 moderated by Dr. Manal Alotibi

Time	Speaker	Affiliation	Topic
8:00am—9:00am			Breakfast
9:00am—9:30am	Zehba A. Raizah +	King Khalid University	Compressible Smoothed Particle Hydrodynamics for Simulating Fluid Flows Through Porous Structures
9:30am—9:50am	Sara Livazovic	Dow Chemical	The Importance of Versatile Skills in Science
9:50am—10:10am	Rabeah Alzaidi	King Fahd University of Petroleum and Minerals	Mitigating Limitations of Machine Learning Adaptation in Porous Media Data
10:10am—10:30am	Marwah M.AlSinan	Saudi Aramco	Synergy between Fracture Permeability Estimation and Machine Learning

Session 4 Industrial Interest in Porous media

Building 9, Room 2325, Nov. 9 moderated by Dr. Tameem Almani

Time	Speaker	Affiliation	Topic
10:30am—10:40am			Coffee break
10:40am-11:05am	Abdulrahman Manea +	Saudi Aramco	Plenary Presentation: Massively Parallel Multigrid and Multiscale Solvers for Scalable Reservoir Simulation in the Exascale Computing Era
11:05am-11:25am	Kundan Kumar +	University of Bergen	Coupled Flow and Mechanics in Fractured Porous Media
11:25am-11:40am	Mohammad Al-Shahrani	King Fahd University of Petroleum and Minerals	Research Activities of KFUPM Department of Mathematics
11:40am-11:55am	Yara Al-Zahid	Saudi Aramco	The Power of Microfluidics-Examples of Enhanced Oil Recovery Related Studies
11:55am-12:10pm	Khaqan Khan	Saudi Aramco	Wellbore Stability beyond Mud Weight

Session 5 Advances in Porous Media Research

Building 9, Room 4223, Nov. 10 moderated by Dr. Bicheng Yan

Time	Speaker	Affiliation	Topic
8:00am—8:40am			Breakfast
9:00am—9:30am	Yalchin Efendiv *	Texas A&M University	Multicontinuum models for porous media flows and applications
9:30am—9:45am	Qinzhuo Liao	King Fahd University of Petroleum and Minerals	Modeling of Scale-Dependent Dispersion using Circulant Embedding and Analysis of Variance
9:45am—10:00am	Fengshou Zhang	Tongji University	Hydro-mechanical coupled analysis of near-wellbore fines migration from unconsolidated reservoirs
10:00am—10:15am	Hussein Hoteit	King Abdullah University of Science and Technology	Applicability and Challenges of Polymer Injection in Porous Media: Visuals at Nano, Micro, and Deci-Scales
10:15am—10:30am	Yongfei Yang	China University of Petroleum, East China	Dynamic Pore Structure and Fluid Distribution Characterization based on CT images

Session 6 Young Talents in Porous Media Research

Building 9, Room 4223, Nov. 10 moderated by Dr. Tao Zhang

Time	Speaker	Affiliation	Topic
10:30am—10:40am			Coffee break
10:40am-11:00am	Ping Hu +	King Abdullah University of Science and Technology	Coupling between intralaminar and interlaminar damage in porous CFRP composites
11:00am-11:10am	Bora Yalcin	King Abdullah University of Science and Technology	Elastic response of porous medium to accumulated slip on complex fault network. A case study from fault map to porous medium permeability alteration
11:10am-11:20am	Abdirizak Omar	King Abdullah University of Science and Technology	Co-optimization of CO2 Storage and Enhanced Gas Recovery Using Carbonated Water and Supercritical CO2
11:20am-11:30am	Ruben Figueroa-Hernandez	King Abdullah University of Science and Technology	Pressure Transient Analysis in Stress Sensitive Face-Damaged Fractured Wells
11:30am-11:40pm	Jie Liu	King Abdullah University of Science and Technology	Transport Behavior of Shale Oil in Organic Pore by Molecular Dynamics Simulation
11:40am-11:50pm	Miguel Corrales	King Abdullah University of Science and Technology	Assessment of CO2 Geological Storage near Riyadh, Saudi Arabia
11:50am-12:00pm	Yuzhu Wang	King Abdullah University of Science and Technology	Permeability Contribution of the Micropore Structures in the Heterogeneous Rock

			Samples with Multiscale Porous Media
12:00am-12:10pm	Jamal Alaamri	King Abdullah University of Science and Technology	4D Pore-Scale Assessment of Rock-to-Rock Spontaneous Imbibition

Note

- All presentations will include a short Q&A at the end (included in the scheduled time and moderated by the host).
- * denotes plenary speakers, and + denotes keynote speakers.
- E-posters presentations will be held in the library sea view area on 2:30pm-3:30pm, Nov. 8th, and all the posters will be exhibited during all the three days.
- Zoom link for virtual speakers and audience:

  Meeting ID: 975 5941 0132

  Join Zoom Meeting: https://kaust.zoom.us/j/97559410132
- Breakfast will be provided at 8:00am everyday morning at the meeting location. Vouchers are gifted in the Conference Bag for lunch and dinner in the Campus Diner. Beverages, fruits and snacks will be served all the time.
- A short introduction of each non-student speaker and the abstracts are attached in the following pages.
- The map of KAUST Inn and Discovery Square, as well as of Campus, are illustrated on the last page to guide you to the meeting room and tour around our university.
- If you need help:

  Emergencies: 012-808-0911

  Tao Zhang: +966 0564859662, tao.zhang.1@kaust.edu.sa

  Jie Liu: +966 0564383650, jie.liu.1@kaust.edu.sa

Title: Impact of salinity contrast on the oil remobilization: micromodel experiments and modelling

Abstract: Low-salinity water flooding is a promising technique for enhanced oil recovery in sandstone and carbonate reservoirs. Numerous mechanisms have been proposed to exaplain the effect of a low concentration of dissolved salts in on water flooding. Most proposed mechanisms involve water transport through the oil phase, due to a salinity contrast. However, up to now, there is insufficient evidence that such a water transport contributes significantly to oil remobilization. In our study, we used three different aqueous solutions and two alkanes in a series of experiments performed in a hydrophilic micro-capillarity or in a hydrophobically coated glass micromodel. With three steps of liquid injection, we created multiple systems of low-salinity water/alkane/high-salinity water in the porous micromodel. Then, the system was continuously monitored for an extended period. The acquired images gave a direct pore-scale observation of the dynamic expansion in the trapped high-salinity water regions and its influence on the oil movement.

We have also performed numerical modelling of ionic diffusive transport through a charged thin film of an aqueous solution between an oil droplet and a solid surface. Simulations are performed by solving the Poisson equation together with the Nernst-Planck flux formula to model electrochemical processes in electro-diffusion problems. One important application of these system of equations to study the interaction of ionic diffusion and thin film hydrodynamics in petroleum engineering. Commonly this is modelled as a two-dimensional axi-symmetric problem. We have developed a thickness-averaged set of equations that allows us to simulate the process as one-dimensional. This reduces the computational time drastically.

Bio: Prof. Hassanizadeh is an Emeritus Professor of Hydrogeology at the Faculty of Geosciences of Utrecht University and Senior Professor with the Center for Simulation Science (SIMTECH), Stuttgart University, Germany. He received his PhD degree in Water Resources Engineering from Civil Engineering Department of Princeton University in 1979.

He is elected Fellow of American Geophysical Union (2002), elected Fellow of American Association for Advancement of Science (2007); has received honorary degree of Doctor-Ingenieur from Stuttgart University (2008); and is a recipient of von Humboldt Prize (2010) and Don and Betty Kirkham Soil Physics Award from

SSSA (2011). He was selected as 2012 Darcy Lecturer by the US National Groundwater Association (2011). He was awarded a research grant of 2.3 MEuro by the European Research Council (2013). He is recipient of Royal medal of honor of The Netherlands, Ridder in de Orde van Nederlandse Leeuw (Knight in the Order of Netherlands Lion), July 2015, and recipient of Robbert E. Horton Medal from American Geophysical Union (2019). He was recently elected to the Academy of Europe (2021).
He is on the editorial boards of Transport in Porous Media (since 1989), Journal of Porous Media (since 2009), among others. He co-founded the International Society for Porous Media (InterPore) in 2008, and has been Managing Director of InterPore since then. He has organized more than 60 conferences, workshops, and short courses, and has been invited or keynote speaker in a large number of international meetings.

Title: Efficient pore-scale simulation of shale gas flows

Abstract: Shale gas flow at the pore scale is very challenging to simulate due to high Knudsen numbers (Kn), low speeds and complicated pore geometries. The direct simulation BGK (DSBGK) method and the discrete velocity method (DVM) are promising methods to simulate three-dimensional (3D) gas flows in the shale rock. We will present the comparative study between these two methods in terms of grid convergence speed, accuracy, CPU time and memory usage in both classical benchmark problems and porous media applications. Generally, the grid convergence of the DSBGK simulation is faster than that of the DVM, which requires a very large number of spatial and molecular velocity grids for convergence. Consequently, the DSBGK simulation is orders of magnitude cheaper than the DVM simulation in terms of the CPU time and memory usage. While the DVM requires a high-performance computing facility to meet the memory demand of several hundreds of gigabyte for simulating a 3D representative porous flow problem, the DSBGK simulation can run on an ordinary laptop. Comparison with other simulation methods based on the same Boltzmann-like equation (e.g., UGKS, DUGKS, DSMC, LVDSMC, LBM) will be discussed as well.

Bio: Dr. Jun Li independently proposed the Monte Carlo molecular simulation method (i.e., the DSBGK method) to efficiently and accurately simulate the low-speed rarefied gas flows of high Knudsen number (e.g., pore-scale shale gas flows, gas flows in MEMS/NEMS, vacuum system and Knudsen pump, membranes and nanotubes), and independently developed the Fortran MPI parallel code NanoGasSim that had been comprehensively validated by the direct simulation Monte Carlo method and the experimental data and successfully applied in real-size rarefied gas flow problems. The DSBGK method is a few orders of magnitude cheaper in terms of the memory usage and CPU time than other possible methods in simulating real 3D low-speed rarefied gas flows. For the study of conventional continuum flows, I proposed an upscaled lattice Boltzmann method (LBM) for Darcy flow simulations and a LBM-Large Eddy Simulation model for the turbulence study, and also independently developed the Fortran MPI parallel code GigaPores using the LBM to study the relative permeability and endpoint saturations for porous media, two-phase flows inside capillary tube, droplet dynamics, movement of contact line, etc.

Title: Simulating acid wormhole utilizing the two-scale continuum model: applications, limitations, and advancement opportunities

Abstract: Acid injection in carbonate reservoirs is a common practice to remove formation damage or enhance a tight reservoir's productivity. Wormholes (i.e., infinite permeability channels) are created upon acid injection, which reduces the pressure drop near the wellbore. In the field perspective, a negative skin of 3 or 4 is created due to wormholes, which is a function of the wormhole's radius and coverage. A successful acid stimulation job has to offer deep penetration and excellent stimulation coverage. Hence, a simulation of wormhole propagation has been an active research area to understand and optimize the process. The two-scale continuum model was recently proposed as an accurate tool to predict wormhole shape and acid efficiency. The model integrates the fluid flow in porous media with reactive transport and heat transfer. This presentation will focus on the application of the two-scale continuum model in both lab and field-scale based on our recent research. We will extend the discussion to the model's limitations, which opens further research and development opportunities.

Bio: Prof. Al Jawad is an Assistant Professor in the Petroleum Engineering Department at KFUPM. He received his Ph.D. degree in Petroleum Engineering from Texas A&M University in 2018, MS in Petroleum Engineering from Texas A&M, and BS in Chemical Engineering from KFUPM. He has been actively involved in research projects regarding acid stimulation, hydraulic fracturing, and unconventional reservoirs. Since joining KFUPM in 2018, Dr. Al Jawad has been a member of several internally and externally funded projects. He has taught several undergraduate and graduate courses in Petroleum Engineering. He led the development of a concentration in unconventional hydrocarbon resources. Also, he established a fully equipped, state-of-the-art lab to study acid stimulation and hydraulic fracturing. He is a technical reviewer for different prestigious journals and has an excellent record of publications on the subject of stimulation.

Title: Effective transport properties of multiphase porous media

Abstract: Prediction of effective properties for multiphase material systems is very important not only to analysis and optimization of material performance, but also to new material designs. We develop a method that is able to predict more accurately and efficiently the effective physical properties of multiphase porous media with complex internal microstructures. A random generation-growth algorithm is highlighted for reproducing multiphase microstructures, statistically equivalent to the actual systems, based on the geometrical and morphological information obtained from measurements and experimental estimations. A high-efficiency lattice Boltzmann solver for the corresponding governing equations is described which, while assuring energy conservation and the appropriate continuities at numerous interfaces in a complex system, has demonstrated its numerical power in yielding accurate solutions. Various applications are provided to validate the feasibility, effectiveness and robustness of this new methodology by comparing the predictions with existing experimental data from different transport processes, accounting for the effects due to component size, material anisotropy, internal morphology and multiphase interactions. The examples given also suggest even wider potential applicability of this methodology to other problems as long as they are governed by the similar partial differential equation(s). For given composition and structure, this numerical methodology is in essence a model with prior validity, without resorting to ad hoc empirical treatment. Therefore, it is useful for design and optimization of new materials, beyond just predicting and analyzing the existing ones.

Bio: Moran Wang is a Professor at Department of Engineering Mechanics of Tsinghua University. After receiving his PhD degree in 2004 from Tsinghua University, he joined the Johns Hopkins University (2004-2006) and University of California (2006-2008) of USA as a postdoctoral fellow. He worked in Los Alamos National Laboratory as an Oppenheimer Fellow from 2008 to 2011. He then joined Tsinghua University as a full professor. He is working on microscale fluid mechanics and thermophysics in porous media. He has authored over 180 peer-reviewed papers on international journals which gained over 9000 times citations based on Google Scholar Reports (H-index: 50). Prof. Wang has been serving as editorial board members for several international journals including “Transport in Porous Media”, “Journal of Porous Media”, “Journal of Geophysical Research-Solid Earth”, “Journal of Fluid Engineering-ASME” and so on. He has delivered over 20 invited talks and been invited to contribute comprehensive reviews on "Physics Reports", "Surface Science Reports", "Material Science and Engineering R: Reports", "Progress in Materials Science", "Nano Today" and so on. He won the Interpore P&G Award for Porous Media Research in 2019.

Title: Reactive Transport Modeling Applications in Oil and Gas Industry: Insights and challenges

Abstract: Quantification and prediction of reservoir quality and reservoir response to the exotic fluid flow are fundamental challenges in the petroleum industry. Reactive transport modeling (RTM) has been considered a “realistic” approach to investigate coupled physical and chemical processes, such as fluid flow in porous media and gas-water-rock interaction through space and time. It can been applied in reservoir quality prediction, reservoir management, well management, and carbon management. RTM improve our fundamental understanding of diagenesis and the spatial and temporal prediction of gas-fluid-rock interactions for solving both geoscience and engineering problems in the petroleum industry. This presentation will introduce this technology and provide a couple of examples of its application.

Bio: Peng Lu is currently a Geological Specialist at EXPEC Advanced Research Center, Saudi Aramco and the Leader of Geology Technology Team of Beijing Research Center, Aramco Asia. He received his Ph.D. degree in geochemistry from Indiana University, U.S.A. His research focuses on integrating field observations, experimental and numerical modeling approaches to investigate the underlying processes and mechanisms of gas-water-rock-interactions, which are pertinent to many urgent energy and environmental problems, such as reservoir quality prediction of petroleum reservoirs, geological carbon storage, toxic metal contaminations, and water quality. He led the development of carbonate and clastic diagenesis modeling software (CarbGen and ClastGen) and a toolbox to seamless couple forward depositional modeling with diagenetic modeling. He received the 2021 Kharaka Award from International Association of GeoChemistry (IAGC), EXPEC Advanced Research Center Awards in 2019 - 2021 and AAPG ACE 2017 Top Presentations Award. He was a finalist for Best Exploration Technology Award – World Oil Awards in 2017. Dr. Lu has more than 40 referred journal publications with a total citation of 1500+ and an H-index of 19, according to Google Scholar. He holds 8 U.S. patents and has additional 12 U.S. patent applications.

Title: Molecular structure at the bulk and interfaces in relation to hydrocarbon and renewable energy production from subsurface and environmental stewardship

Abstract: It is now widely believed that the increase in concentration of CO_2 in the atmosphere from some 320 ppm in 1960 to more than 420 ppm in 2020 is a main cause of global warming. The vibrational motions of carbon and oxygen atoms of CO_2 molecules relate to heat absorption radiated from the Earth.
A significant amount of CO_2 emitted to the atmosphere is from fixed-sources such as 1: power generation, 2:steel and cement production, and 3: oil and gas production. CO_2 can be potentially stored permanently in subsurface aquifers. It can be also used in many CO_2-IOR, and CO_2 fracking and a working fluid for geothermal energy production and other uses. The oil and gas production can be also made more efficient through use of engineered molecules at very low concentration.
The presentation focuses on molecular structure in bulk and change in both the bulk and the fluid-fluid and fluid-solid interfaces. CO_2-viscosification, fluid-fluid interface elasticity increase, and CO_2 fracturing in relation to fluid-solid interface energy will be discussed. All the topics are in direction of stewardship of the environment and process efficiency..

Bio: Abbas Firoozabadi has a PhD degree from the Illinois Institute Technology and did post-doctoral research at the University of Michigan, Ann Arbor, MI. Professor Firoozabadi has taught graduate level courses on equilibrium and irreversible thermodynamics at the University of Texas-Austin, Imperial College London, Yale University, Tokyo University, Rice University, and Peking University. He has established a research consortium at the Reservoir Engineering Research Institute (RERI) in Palo Alto, Ca with the funding from major energy companies in the US and abroad, and US-DOE. His published work covers multi-component-multiphase flow in fractured media and equilibrium and flow in unconfined and confined media. He has received four of the five major awards of the Society of Petroleum Engineers (SPE) including the Anthony Lucas Gold Medal. Professor Firoozabadi is a member of the US National Academy of Engineering (NAE).

Title: Application of CT scanning in tackling challenges in upstream E&P

Abstract: There are a range of questions and challenges in upstream E&P that are difficult to tackle because proper quantification and visualization simply is lacking when it comes to the subsurface. Core material, when it is available can provide most answers. However, its not always available either for technical or confidentiality reasons and sometimes the core analysis is also deceitful. In this talk, two studies are presented where some of the challenges can be bypassed to the involvement of CT scanning. In one case, a central Asian reservoir was wrongfully associated with a specific permeability because of a micrometer scale layering that was invisible to the core scale measurements but visible in CT. In another case, it was shown that CT measurements on cuttings and subsequent modeling could compensate for the absence of core from long horizontal sections of a chalk reservoir.

Bio: Dr. Solling is currently a Senior Research Scientist and the Program Lead of the Oilfield Chemicals program in the Center for Integrated Petroleum Research, College of Petroleum Engineering & Geoscience, King Fahd University of Petroleum and Minerals. Dr. Solling has a background in Physical Organic Chemistry as studied with ultrafast lasers, and interest that came from his postdoc years at Caltech under the guidance of late Professor Ahmed H. Zewail. After a three year position as a Researcher at Risø National Labs, Dr. Solling became Associate Professor (Organic Chemistry) at the University of Copenhagen and worked on ultrafast phenomena until he was appointed team lead at Maersk Oil Research and Technology Centre in Qatar. He returned to the University of Copenhagen as a Full Professor in 2016 to set up an educational specialization in Chemistry for the oil and gas sector. In 2018 he moved to the Kingdom of Saudi Arabia to be a part of CIPR.

Title: Specific Surface Area versus Porosity from Digital Images

Abstract: By computing the total porosity and specific surface area for a number of segmented digital volumes of natural sandstones, carbonates, and granular samples, as well as their subvolumes, we observe fairly tight trends between those two variables. The emerging picture is different for low-to-medium porosity rocks from that for high-porosity granular samples. In the former, increases with increasing , while the behavior is opposite in the particulates. We explain these trends by invoking simple theoretical derivations where the consolidated low-to-medium porosity samples are modeled as solids with inclusions, while the particulates are represented by packs of grains. While in the former is linearly proportional to , it is linearly proportional to in the latter. The digital data are fairly accurately matched by the respective theoretical curves with the pore- and grain-size statistics extracted from the digital volumes. This fact arguably means that the trends obtained here from microscopic digital volumes are valid at a much coarser core and reservoir scale.

Bio: Jack Dvorkin is Program Leader of the Rock Science Program at the College of Petroleum Engineering and Geosciences at King Fahd University of Petroleum and Minerals in Dhahran, Saudi Arabia. Jack earned his Ph.D. in Continuum Mechanics from Moscow State University in the USSR in 1980. Between 1989 and 2017 he worked at the Stanford Rock Physics Program. He has developed many of the rock physics theoretical models currently in use. Jack is an SEG Honorary Member. He has published over 170 technical papers, 5 books, and 9 US patents. He has supervised over 30 Ph.D. and M.S. students. Jack's current interests are in experimental and theoretical rock physics; wireline data analysis for predictive analytical models; seismic data interpretation for physical properties of the subsurface; and digital rock physics.

Title: Underground storage between potential and opportunities

Abstract: Climate change has emerged as a historic challenge facing the planet. Carbon dioxide is one of the significant contributors to greenhouse gases accumulation. Thus, several initiatives are proposed to meet the energy demand at reduced emissions, including carbon capture and storage (CCS) and hydrogen storage and utilization. The underground storage of both carbon dioxide and hydrogen in porous geological formations and deep saline aquifers could theoretically provide very high storage capacities to store both. However, several parameters need to be investigated to optimize the storage process, including gases diffusivity in porous media, potential reactions of the injected gases, and the storage complex. Furthermore, the seals' integrity and gases/fluids flow and transport in complex porous media should be evaluated before and during the storage of the injected gases.
We will present an overview of the underground storage concept and objectives. Also, we will discuss the in-situ hydrogen formation as a clean energy source. We will elaborate on the role of porous materials as one of the advanced materials' key enablers to achieve in-situ conversion. Both challenges and opportunities will be highlighted and discussed to leverage the contribution of advanced materials and simulation to unlock the underground storage potential.

Bio: Dr. Nouf AlJabri is a Petroleum engineer with the Reservoir Engineering Technology Division at Saudi Aramco's EXPEC Advanced Research Center (EXPEC ARC). Nouf holds a PhD and MSc in Chemical Engineering from KAUST. She worked as visiting scientist with prof. Timothy M. Swager at MIT to design and synthesize novel advanced materials to resolve key upstream challenges. Her research focused on developing new disruptive concepts for upstream nanotechnologies and nanomaterials. She is currently spearheading research efforts on novel functionalization of nanomaterials for targeted-delivery of EOR-chemicals.

Title: The Design and Synthesis of Hierarchical Faujasite Zeolite

Abstract: Efforts to overcome diffusional limitation in microporous zeolites have been directed towards the design of hierarchical zeolite structures. Hierarchical zeolites contain highly interconnected networks of zeolitic micropores combined with meso- and/or macropores. Interest in these materials stems from the higher reaction rates, improved selectivity, resistance to deactivation, and novel adsorption behavior that they exhibit in comparison to the typical zeolites that only have micropores. Among the synthesis approaches, repetitive branching by rotational intergrowth holds promise for industrial implementation due to its simplicity and lower cost as it is a one-step synthesis which uses simple structure-directing agents or additives compared to hard and dual-soft templating approaches. Faujasite is one of the most widely used catalysts, mainly in fluid catalytic cracking (FCC) of heavy petroleum, where coking is significant. Hierarchical Faujasite, with enhanced micropore accessibility, can reduce the detrimental effect of coking. Hierarchical Faujasite has been prepared by post synthetic treatment, or by using soft-templates or hard templates, adding extra cost and complexity to the synthesis. House-of-card assembly of Faujasite sheets by repetitive branching has been previously reported using either organosilane surfactants or lithium or zinc salts. In this talk, I discuss inorganic syntheses approaches, using sodium aluminosilicate gels, to prepare hierarchical Faujasite structures. These approaches utilize the intrinsic growth kinetics of crystals to tune the particle morphology

Bio: Maryam Khaleel joined the Department of Chemical Engineering at the Petroleum Institute in May 2016 as an Assistant Professor. She received her Bachelors in Chemical Engineering from the Petroleum Institute, Abu Dhabi (honors with distinction, 2011) and her PhD from the department of Chemical Engineering & Materials Science at the University of Minnesota, U.S.A. (2015). Dr. Khaleel worked on the synthesis and characterization of hierarchical Faujasite zeolites, in particular house-of- cards assembly of Faujasite sheets and nano-sized Faujasite crystals. Her work focused on developing a better understanding of the nucleation and growth of such materials formed by FAU/EMT intergrowth using transmission electron microscopy imaging (room temperature and cryogenic) and diffraction. Her current research interests are on the nanoscale engineering of porous materials, including zeolites and MOFs, and bi-functional materials for applications in separation and catalysis, particularly in sustainable chemistry (e.g. CO2 capture, hydrogen production and purification, and production of platform chemicals from CO2 and biomass). She is also interested in thermal and electrical energy storage. Dr. Khaleel is the recipient of several awards including the L'oreal Regional Talents Program (2020) and Sheikh Rashed Award for Scientific Achievement (2017).

Title: Compressible Smoothed Particle Hydrodynamics for Simulating Fluid Flows Through Porous Structures

Abstract: The numerical and experimental studies have been presented on flows inside porous media in closed cavities, using different methods to solve the equations system describe the case. A stabilized incompressible smoothed particle hydrodynamics (ISPH) method will be presented for simulating fluid flows through porous structures. In the ISPH algorithm, a semi-implicit velocity correction procedure is employed and the pressure is implicitly evaluated by solving the pressure Poisson equation. Evaluated pressure has been improved by relaxing the density invariance condition to formulate a modified pressure Poisson equation. The effect of eddy viscosity by using a sub-particle scale turbulence model is introduced to the entire computational domain. The key point for the application to the non-Darcy flows is to include the porosity and drag forces of the medium into the ISPH method.

Bio: Zahba Al Raizah is a professor of applied mathematics at King Khalid University. She received her Ph.D. in Computational Fluid Dynamics in 2010. She has more than 65 papers in the field of simulating the convection heat transfer of nanofluids inside cavities and porous media field.

She received the Research Excellence Award at King Khalid University in 2020 for publishing in highly rated journals.

She worked leadership positions at King Khalid University, as department head and vice dean, then dean of the College of Science for six years, and currently deputy dean of scientific research..

Title: The Importance of Versatile Skills in Science

Abstract: If 2020 has taught us anything, it is that anything and everything can change in a day. The future and outlook of work and workforce might be changed forever. How do we keep up with ever-changing environment and how to stay relevant in this competitive, sometimes volatile economy? More and more research, evidence and overall experience is showing that versatility and adaptability of our skills, be that technical skills or soft skills, is among crucial factors that contribute to our future success. What are those skills, how to obtain versatility in skills and eventually use them at your advantage, will be discussed during the presentation.

Bio:

Title: Mitigating Limitations of Machine Learning Adaptation in Porous Media Data

Abstract: Machine learning approaches have exhibited significant potential in modeling and prediction tasks while eliminating the need for constructing underlying analytical formulations. However, caution must be taken with the use of machine learning models to avoid overestimations of their performance and opaqueness of the learning models themselves. In this talk we address common limitations of applying ML models in porous media data with spatially continuous features and propose approaches for mitigation. As a case study, we target the inter well saturation prediction problem to demonstrate our findings.

Bio: Rabeah Alzaidy is an assistant professor of Computer Science at KFUPM, Saudi Arabia and an AI Consultant at the Saudi Data and AI Authority (SDAIA). Her research interests include multi-modal information retrieval, machine learning, deep learning natural language processing and semantic structuring of big data. Rabeah holds a PhD degree in Computer Science and Engineering from the Pennsylvania State University, USA and a master degree in information systems security from Concordia University, Canada. From 2017-2019 she held positions of postdoctoral fellow at Penn State and then at KAUST. Rabeah has authored several papers at top-tier reviewed conferences and journals such as DIIN, AAAI and The WebConf. She is member of IEEE, AAAI, ACM and is PC chair and editor for leading international AI conferences and journals.

Title: Synergy between Fracture Permeability Estimation and Machine Learning

Abstract: The permeability of fractures (including natural and hydraulic) are essential parameters for the modeling of fluid flow in conventional and unconventional fractured reservoirs. However, traditional analytical (CL-based) models used to estimate fracture permeability show unstable performance when dealing with different complexities of fracture cases. This work presents a data-driven, physics-included model based on machine learning as an alternative to traditional methods.

The workflow for the development of the data-driven model includes four steps. Step 1: Identify uncertain parameters and perform Latin Hypercube Sampling (LHS). We first identify the uncertain parameters which affect the fracture permeability. We then generate training samples using LHS. Step 2: Perform training simulations and collect inputs & outputs. In this step, high-resolution simulations with parallel computing for the Navier-Stokes equations (NSEs) are run for each of the training samples. We then collect the inputs & outputs from the simulations. Step 3: Construct an optimized data-driven surrogate model. A data-driven model based on machine learning is then built to model the nonlinear mapping between the inputs and outputs collected from Step 2. Herein, Artificial Neural Network (ANN) coupling with Bayesian optimization algorithm is implemented to obtain the optimized surrogate model. Step 4: Validate the proposed data-driven model. In this step, we conduct blind validation on the proposed model with high-fidelity simulations.

We further test the developed surrogate model with newly generated fracture cases with a broad range of roughness and tortuosity under different Reynolds numbers. We then compare its performance to the reference NSEs solutions. Results show that the developed data-driven model delivers good accuracy exceeding 90 % for all training, validation, and test samples. This work introduces an integrated workflow for developing a data-driven, physics-included model using machine learning to estimate fracture permeability under complex physics (e.g., inertial effect). To our knowledge, this technique is introduced for the first time for the upscaling of rock fractures. The proposed model offers an efficient and accurate alternative to the traditional upscaling methods that can be readily implemented in reservoir characterization and modeling workflows..

Bio: Marwah AlSinan joined Saudi Aramco in 2013 as a Petroleum Engineer, working with the Reservoir Engineering Technology Division in the Exploration

and Petroleum Engineering Center – Advanced Research Center (EXPEC ARC). Her research interests include multi-phase flow in fractures, CO_2 sequestration and applications of Nuclear Magnetic Resonance (NMR) in porous media.
Marwah received her B.S. degree in Petroleum and Natural Gas Engineering from Pennsylvania State University (PSU), Pennsylvania, USA, in 2013. In 2017, she received her M.S. degree in Petroleum Engineering from Imperial College, London, UK for her thesis in Non-Darcy Flow in Natural Fractures.

Title: Massively Parallel Multigrid and Multiscale Solvers for Scalable Reservoir Simulation in the Exascale Computing Era

Abstract: Since the 1980's, hydrocarbon reservoir simulation has been among the very few applied applications that always push the limits of scientific computing to uncharted territories. This is the case as reservoir simulation models typically involve massive special sizes with multiscale heterogeneity, complex physical processes with multiscale temporal resolutions, large degrees of uncertainty and huge numbers of operating parameters, which all drive the computational demands for reservoir simulation beyond tractable limits. To cope with such computational demands, the typical approach taken in practical settings is to trade off the models size/complexity to levels that are computationally feasible. Nonetheless, there has been continuous evolution in massively parallel and high-performance-computing (HPC) architectures, such as GPUs, leading us to the doorstep of exascale computing era. This remarkable computational power offers great opportunities to simulate reservoir models with less (or possibly no) reduction in their sizes/complexities. However, such computational power requires extremely scalable kernels to realize its full potential. As the solver is typically the most computationally demanding and challenging to scale kernel during reservoir simulation, utilizing HPC architecture to speed-up the solver is key to having scalable reservoir simulation on such emerging architectures. In this session, we highlight some promising developments in multigrid and multiscale solvers on HPC architectures, which have the potential to pave the way to highly scalable reservoir simulation in the exascale computing era.

Bio: Dr. Abdulrahman M. Manea is a computational research scientist at the Upstream Advanced Research Center in Saudi Aramco. His current research interests include parallel linear and nonlinear solvers, large-scale parallel simulation, high-performance scientific computing, and gridding and discretization. He has co-authored more than 20 research papers across various conferences and journals in reservoir simulation and computer science. Manea is an active member of several scientific societies, e.g., SIAM and SPE, and has been serving on several technical committees for local and international conferences, including the Science 20 (S20) Group, the SPE Reservoir Simulation Conference and the International Petroleum Technology Conference (IPTC). He holds a PhD degree in energy resources engineering with a minor in computational and mathematical engineering from Stanford University, and master's and bachelor's degrees, both in computer science, from King Fahd University of Petroleum and Minerals, Saudi Arabia.

Title: Coupled Flow and Mechanics in Fractured Porous Media

Abstract: Numerous applications of subsurface engineering involve injection and extraction of fluids. Examples include geothermal energy extraction, nuclear waste storage, carbon sequestration, petroleum engineering applications, and energy storage. These anthropogenic activities involve a complex set of processes involving flow, thermal, chemical reactions, and mechanical effects all possibly coupled to each other. These complex sets of processes interact with the complex geology that involves ubiquitous fractures and faults. The network of fractures form the primary conduit of flow and transport and furthermore, act as the most vulnerable regions for mechanical instability. The interaction of processes and the complex geometry of fractures brings computational and mathematical challenges in the simulation of these processes. The fractured medium is generally anisotropic, heterogeneous, and has substantially discontinuous material properties spanning several orders of magnitude.
Our objective is to study coupling of flow and geomechanics in a fractured porous medium setting. We present a mixed dimensional model for a fractured poro-elasic medium. The fracture is a lower dimensional surface embedded in a bulk poro-elastic matrix. The flow equation on the fracture is a Darcy type model that follows the cubic law for permeability. The bulk poro-elasticity is governed by fully dynamic Biot equations. The resulting model is a mixed dimensional type where the fracture flow on a surface is coupled to a bulk flow and geomechanics model. There are two directions in which our work contributes to. The first is in extending Biot equations to include fracture flow model. The second is in considering different time schemes for the Multiphysics modelling. We consider finer time steps for the flow and coarser time steps for the mechanics. We provide a rigorous mathematical foundation in both directions.

Bio: Kundan Kumar is an Associate Professor in the Department of Mathematics at the University of Bergen, Norway. His research interests are in the upscaling and numerical methods for coupled problems with applications in porous media. He did his PhD at Eindhoven (2012) followed by Postdoc at the Oden Institute, University of Texas at Austin (2012-14). Prior to his current position in Bergen, he had a brief stint at Karlstad University, Sweden. He has been awarded the SIAM Early Career Prize for Geosciences 2017 and Lauritz Meltzer Prize for Young Researcher at the University of Bergen..

Title: Research Activities of KFUPM Department of Mathematics

Abstract: In this short talk, we shall give an overview of the diverse research activities carried out by the faculty and students of the department of mathematics at KFUPM. The research interests cover a vast range of areas of mathematics, statistics and financial mathematics. This talk aims to put a spotlight on the department fundamental research.

Bio: Prof. Mohammed Alshahrani is an associate professor of mathematics in the department of mathematics at King Fahd University of Petroleum and Minerals (KFUPM). Alshahrani received his PhD in optimal control under the supervision of Professor Boris Mordukhovich from KFUPM. Dr. Alshahrani' s teaching experience extends for over 20 years. His research interests include various areas of mathematical programming. In recent years, his focus is on numerical optimization.

Title: The Power of Microfluidics- Examples of Enhanced Oil Recovery Related Studies

Abstract: Waterflooding and improved/enhanced oil recovery (IOR/EOR) technologies aim to boost the natural reservoir energy and result in favorable interactions with the reservoir rock and fluids to recover incremental oil. The conventional way to study the effectiveness of any IOR/EOR method in the laboratory is through core-flooding. However, commonly used core-flooding systems will not provide the direct visualization of the fluid flow and pore scale interactions occurring in porous media. Such pore scale visualization data will add value to complement the core flood data to accurately characterize the flow behavior and better understand the recovery mechanisms. Additionally, the value of such pore-scale visualization can extend beyond EOR and is valuable for all flow in porous media, including for example near wellbore treatments. In this talk, we describe novel microfluidic technologies that can enable, pore-scale visualizations in representative porous mediums. New frontiers in micro-scale studies and microfluidics will be discussed. This next generation platform offers the great potential to quickly screen different recovery agents, optimize the testing conditions for core floods.

Bio: Yara Alzahid is a petroleum scientist working in EXPEC Advanced Research Center at Saudi Aramco. She obtained her Master degree from King Abdullah University of Science and Technology (KAUST) and PhD in Petroleum Engineering from the University of New South Wales (UNSW). She was the recipient of UNSW Dean's Award for outstanding PhD thesis. Since starting her research career in 2014, she published 12 technical papers, 6 of which are peer-reviewed journal publications. She has 1 granted patent from the US patent office and disclosed 4 more patents. Her research interests include chemical enhanced oil recovery and fluid flow and transport in porous media. Yara has led many research project collaborations and initiatives within her department. She is extremely passionate about diversity and inclusion, particularly encouraging women to pursue careers in STEM majors. She is establishing Diversity and Inclusion committee, a newly added committee within SPE-KSA. Additionally, she recently established a local section of the Society of Women Engineers (SWE) here in Dhahran.

Title: Wellbore Stability beyond Mud Weight

Abstract: Drilling wells with stable and good quality wellbore is essential to minimize drilling difficulties, acquire reliable openhole logs, run completions successfully and ensure well integrity during stimulation. Wellbore stability is a complex phenomenon affected by geomechanics, drilling parameters, bottom-hole assembly (BHA) design as well as subsurface structural and rock heterogeneities. Conventionally, wellbore stability for a particular well trajectory is linked to an interplay of in-situ stresses, rock strength properties and effective mud support provided by drilling mud. Consequently, when a wellbore is unstable (over-gauge) for a given subsurface stress conditions, it is believed that mud support was insufficient to counter the stress concentration around wellbore wall leading to stress-induced rock compressive failure (breakouts). Hence, increasing mud weight for the next well based on model validation and recalibration using offset wells data is a common approach to address the wellbore stability problem. However, it has been observed that even wells drilled with higher mud weight in the same vicinity and under similar subsurface conditions, sometimes, exhibit more unstable wellbore condition (deeper borehole failure) in comparison with an offset well (Figure-1). This observation contradicts the conventional approach of linking wellbore stability to stresses and rock strength properties alone. While it is reported in literature that excessive drill-string vibrations and certain BHA configurations can result in severely enlarged wellbore, the safe limits of main drilling parameters responsible for these enlargement have not been fully understood. The objective of this paper is to analyze the wellbore stability considering not only the geomechanical effects but also taking into consideration the effect of drilling parameters to explain the observed anomalous wellbore stability problem (Figure-1).
The analysis showed that well drilled with a higher mud weight but yet showing more unstable wellbore compared with its offset well was in fact drilled with more aggressive drilling parameters (notably drill-string surface rotational speed and mud flow rates). When drilling parameters are more aggressive, the added disturbance to the wellbore wall would causes more severe wellbore enlargements. Accounting these enlargements to stress-induced failure alone would result in unrealistic in-situs stress estimation and hence a very high mud weight predictions to keep wellbore stable. While higher mud weight (theoretically) helps stabilize the wellbore, it can lead to other detrimental consequences including formation damage, mud losses and risk of differential

stuck pipe. We used a more practical approach to address this issue by recommending an optimum weight to address stress-induced wellbore failure together with specifying safe limits of drilling parameters to minimize wellbore damage due to downhole vibrations. The findings were implemented in subsequent wells resulting in more stable wellbore with hole condition meeting logging and completion requirements as well as avoiding drilling problems.

Bio: Khaqan Khan is a geomechanics subject specialist with Saudi Aramco, where his role is to assist various aspects of field development activities focused on well planning, drilling, completions and stimulation. Prior to Saudi Aramco, he worked with Schlumberger as a lead geomechanics engineer and regional geomechanics manager in the Middle East., with GeoMechanics International Inc. (GMI) as a geomechanics specialist and with KFUPM as a geomechanics engineer. During his 20+ years of experience, he managed and technically led several consulting projects on geomechanics aspects of reservoir management and field development. He earned MS degree from KFUPM in civil (geotechnical) engineering and published several articles on geomechanics.

Title: Multicontinuum models for porous media flows and applications

Abstract: In this talk, we will start with some main concepts in multiscale modeling including numerical homogenization and multiscale finite element methods. Our goal is to model processes in multiscale media without scale separation and with high contrast. We assume that the coarse grid doesn't resolve the scales and the contrast. To deal with these problems, I will introduce multiscale methods that use multicontinua approaches. These approaches use additional macroscopic variables. I will discuss the convergence of these approaches and show that these methods converge independent of the contrast. The multicontinua approaches can benefit from machine learning techniques, which I will discuss. I will also consider how multiscale methods can be used for temporal splitting. High contrast brings stiffness to the system, which requires small time steps. We will introduce partial explicit methods that construct time discretizations with the time stepping that is independent of the contrast.

Bio:

- 2020 SIAM Fellow
- Honorary Professor from North Eastern Federal University, Russia, 2019
- 2017 Class of Fellows of AMS
- Plenary Speaker, International Society of Porous Media, May 2015
- 45 minute Invited Talk, International Congress of Mathematicians, South Korea, 2014 (the article in SCIENCE, TAMU)
- Plenary talk, SIAM Geosciences 2011.
- QRI Scolar, 2011
- Fraunhofer Bessel Award (Alexander von Humboldt Foundation), 2010
- The young researcher fellowship of Sixth U.S. National Congress on Computational Mechanics, August 2001
- W. P. Carey Prize for outstanding thesis work in applied mathematics, California Institute of Technology, 1999

Title: Modeling of Scale-Dependent Dispersion using Circulant Embedding and Analysis of Variance

Abstract: Accurate description of solute transport in porous media is very important for remediation of contaminants in aquifers. The transport process is strongly affected by the scale-dependent dispersion. In order to analyze the characteristics of dispersion, we present a new method combining the circulant embedding and the analysis of variance. We also introduce an interpolation process to significantly reduce the computational cost. The proposed method is validated in various tests and accurately matches the results from the exact references. We find that the dispersion is greatly affected by the impervious lateral boundaries. The method is applied to the Borden site and provides a better explanation of the observed data after considering the effect of vertical boundaries. These results show that our method could serve as a promising tool for efficient computation in groundwater remediation.

Bio: Dr. Qinzhuo Liao is an Assistant Professor at Department of Petroleum Engineering, King Fahd University of Petroleum & Minerals (KFUPM) since 2017. He was a postdoctoral researcher in Stanford University and Peking University from 2015 to 2017. He received his Ph.D. degree in Petroleum Engineering from University of Southern California in 2014 and his B.S. degree in Mechanical Engineering from Peking University in 2009. His research interests include computational methods for flow and transport in porous media, uncertainty quantification, history matching, upscaling and machine learning.

Title: Hydro-mechanical coupled analysis of near-wellbore fines migration from unconsolidated reservoirs

Abstract: We presents a numerical investigation of production-induced migration of fine sands towards a wellbore deeply penetrated in a gap-graded sediment. The solid-fluid interaction is simulated by coupling the discrete element method (DEM) and the dynamic fluid mesh (DFM). The model is capable of naturally capturing particle movements and spatiotemporal variations of hydraulic properties of the sediment at the pore scale. The results show that fine particles are mobilized by radial flow under an imposed hydraulic gradient, and the increase of the hydraulic gradient causes an increase in the fines production. The presence of fine particles affects the process of fines migration through two competing mechanisms. Under a low fine content, fine sands mainly serve as the fines production source, and thus fines production is enhanced as the fine content increases up to a critical value, beyond which fines production is weakened with a further increase in the fine content since the blocking effect gradually dominates. A barrier layer is likely formed during sand migration due to settling and jamming of fine sands at the throats of pores, as fine sands migrate with the radial flow towards the wellbore.

Bio: Fengshou Zhang is a Changjiang Scholar Chair Professor in the School of Civil Engineering at Tongji University. His research direction is multi-field coupling of rock mechanics and its application in deep earth engineering such as shale gas and dry hot rock. He published more than 120 papers and won the Future Leaders Award (2015) and the Early Career Award (2018) of American Rock Mechanics Association (ARMA), and the first Qian Qihu Award of Chinese Society of Rock Mechanics and Engineering (2020).

Title: Applicability and Challenges of Polymer Injection in Porous Media: Visuals at Nano, Micro, and Deci-Scales

Abstract: One challenge in the Oil Industry is to sustain production to secure current supplies and meet demand with tighter environmental constraints and economic margins, maturing oilfields, and lagging exploration. Boosting recovery factors beyond waterflood potential from heterogeneous reservoir formations requires nontraditional water-based (chemical-EOR) or gas-based EOR schemes. Polymer flood is the most commonly used chemical-EOR scheme. Yet, its deployment is often associated with challenges related to the molecular and rheological characteristics of the polymer selected, efficacy at the reservoir conditions, reaction with the formation rock, well injectivity, and others. In this talk, we briefly highlight some lessons learned from several field implementations, including successes and failures. To investigate the challenges, we develop a new approach to visualize the dynamics of polymer flow and transport using microfluidics and fluorescence microscopy. We show, for the first time, direct visualization of the three main mechanisms underlying polymer retention in porous media. This visualization was possible by developing a new fluorescent-labeled polymer. The findings provide a new perspective of polymer flow and transport in porous media and highlight the limitations of some polymer evaluation practices in the industry.

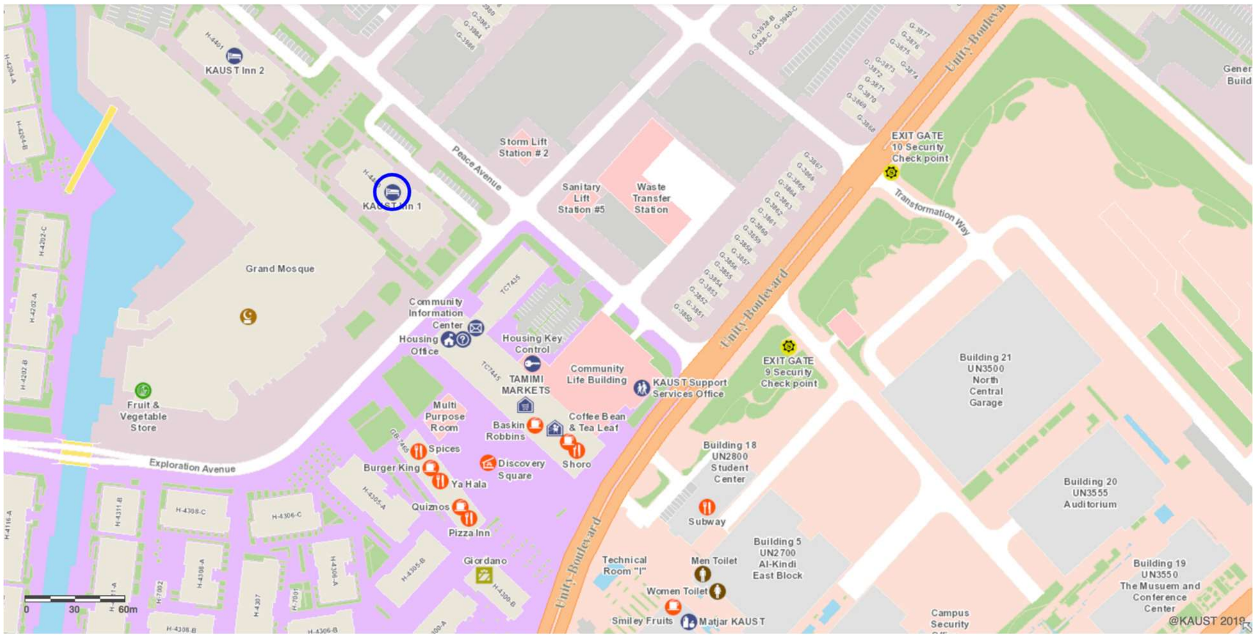
Bio: Hussein Hoteit is an Associate Professor and Program Chair of the Energy Resources and Petroleum Engineering program at KAUST. He received his Ph.D. from the University of Rennes, France, in 2002. Prof. Hoteit then worked for different Oil&Gas companies for about 15 years, where he conducted R&D projects related to chemical-EOR, CO2-EOR, steam flood, and unconventional resources. Prof. Hoteit's current research includes chemical EOR, geological CO2 storage, modeling fractured reservoirs, and reservoir simulation development. Prof. Hoteit earned several SPE awards, including SPE distinguished lecturer in 2009, and served as Associate Editor for SPE Journal for more than ten years.

Title: Dynamic Pore Structure and Fluid Distribution Characterization based on CT images

Abstract: Digital rock technology is developing rapidly, especially with the increasing development of unconventional resources. This presentation will introduce digital rock related experiments. Pore structure analysis and multi-phase flow simulation are followed based on the above digital rock and pore network models. With the help of X-ray computer tomography images, microcosmic oil distribution in sandstone, fracture stress sensitivity, temperature influence, and pore-scale CO2 dissolution will be studied..

Bio: Yongfei Yang is a professor, vice dean of School of Petroleum Engineering at China University of Petroleum (East China). He is an active InterPore member, acting as secretary-general of China InterPore Chapter, secretary of InterPore Foundation and the Chair of Thematic Workshops Committee. He is the associate editor of Journal of Natural Gas Science and Engineering (JNGSE) and editorial board member of the Journal of Petroleum Science and Engineering (JPSE). His research interests include theory and applications of fluid flow in porous media, the applications of digital rock and pore network model technology in oil and gas field development, etc. He is the principal investigator of 10+ research projects supported by the National Natural Science Foundation of China, the National Natural Science Foundation of Shandong Province, the Ministry of Education, and 10+ projects supported by oil companies in China. He has published more than 100 journal papers in the Chemical Engineering Journal, Water Resources Research, Fuel, and Journal of Geophysical Research-Solid Earth, and others. He has authorized 10+ Chinese patents and 3 American/Australia patents. Yang holds a BASc, an MASc, and a PhD, all in petroleum engineering, from the China University of Petroleum (East China). During Sep. 2008 and Aug. 2009, he studied in Heriot-Watt University, Scotland UK as a visiting PhD student.

Kaust Inn & Discovery Square



Campus