第二届国际多孔介质协会中国年会
暨第四届数字岩心分析技术国际研讨会

The 2nd China InterPore Conference on Porous Media & the 4th International Conference on Digital Core Analysis

会议指南

Conference Guide

中国，青岛
Qingdao, China

2018 年 7 月 8 日-11 日
July 8-11, 2018

主办单位：中国石油大学(华东)

国际多孔介质协会中国分会

中国力学学会渗流力学专业组

中国石油学会青年工作委员会

青岛市科学技术协会

承办单位：中国石油大学（华东）油气渗流研究中心

协办单位：青岛腾跃泰合商务服务公司

媒体宣传：中国渗流网　阳光石油论坛　石油 Link　桔灯勘探

会议赞助：卡尔蔡司（上海）管理有限公司　王宽诚教育基金

By: China University of Petroleum (East China)

InterPore China Chapter

Chinese Society of Theoretical and Applied Mechanics

Chinese Petroleum Society

Qingdao Association for Science and Technology

Research Center of Multiphase Flow in Porous Media of UPC

Sponsors:

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会议须知

欢迎各位专家参加本次会议，衷心祝愿您能在中国石油大学（华东）度过一段美好的时光！现将会务有关事项告知如下：

一、HSE 提示：

火警 119，匪警 110，交通事故报警 122，医疗急救 120

二、会议日期：

2018 年 7 月 8 日-11 日

2018 年 7 月 8 日全天报到；

报到地点：青岛市黄岛区蓝海金港大饭店

三、会议地点：

中国石油大学（华东）南门逸夫楼一层会议室

四、用餐及乘车安排：详见《日程安排》

自助餐用餐时间：

早餐：06:30—10:00

午餐：11:30—14:00

晚餐：17:30—21:30

五、注意事项：

1、会议工作语言是英文，会议提供同声传译；

2、请按时到会，服从该会议统一安排，遵守作息时间和酒店的有关规定；

3、会场禁止吸烟，会议期间请将手机设置为静音状态，接打电话请到会议室外。

六、会 务 组：设在蓝海金港大饭店

成　员：杨永飞　15192082829

张文杰　13061362783

杨海元　13863994895

Conference Notice

On behalf of the Organizing Committee, we warmly welcome you to the conference, wish you to have a pleasant and memorable experience in the beautiful coastal city of Qingdao. The conference notices are shown as follows:

1 HSE

Fire Alarm: 119

Emergency Medical Services: 120

HSE Contact Person: Yongfei Yang 0086 15192082829

2 Conference Schedule (For details, see attached Conference Agenda)

July 8th, 2018, Sunday: Registration and Accommodation

July 9th, 2018, Monday: First Day Conference

July 10th, 2018, Tuesday: Second Day Conference

3 Conference Location (For details, see attached Venue and Route)

First floor conference room of Yifu Building, China University of Petroleum (East China)

4 Hotel Meal Time

Breakfast: 06:30-10:00, bring the room card and show it (first floor of hotel);

Buffet Lunch: 11:30-14:00, the buffet tickets are in the bag (first floor of hotel);

Buffet Dinner: 17:30-21:30, the buffet tickets are in the bag (first floor of hotel).

5 Conference Notes

(1) The working language is English and the conference provides simultaneous interpretation.

(2) Please attend the meeting on time, obey the arrangement of the meeting, observe the rest schedule and the relevant regulations of the hotel;

(3) During the conference, please adjust your cell phone to mute state.

6 Conference Contact

Yongfei Yang: 0086-151 9208 2829

Wenjie Zhang: 0086-130 6136 2783

Haiyan Yang: 0086-138 6399 4895

日程安排(Conference Agenda)

July 9th, 2018, Monday

08:30 - 08:40	**Opening Ceremony** *Leader from University*
08:40 – 08:50	**Introduction of InterPore** *Oleg Iliev, Fraunhofer Institute for Industrial Mathematics ITWM, Germany*
Session 1	**Chairman：Jun Yao, Kai Zhang**
08:50 - 09:20	Machine Learning in the Subsurface *Dongxiao Zhang, Peking University, China*
09:20 - 09:45	Multiscale Simulation for Gas Flow in Micro/nano Pores of Deep-Seated Rocks *Moran Wang, Tsinghua University, China*
09:45 - 10:10	Stable and scalable sequential schemes for compositional simulation *Arthur Moncorgé, TOTAL E&P,UK*
10:10-10:45	**Group Photo & Tea break**
Session 2	**Chairman：Hossein Hejazi, Yongfei Yang**
10:45-11:10	A Divide-and-Conquer Method for Large-Scale Water Flooding Optimization *Kai Zhang, China University of Petroleum (East China), China*
11:10-11:35	Multiphysics simulations of electrochemical devices using pore network modeling *Jeff Gostick, University of Waterloo, Canada*
11:35-12:00	Digital Rock Physics for Petro-physical Analysis of Reservoir Rocks: Challenges and Opportunities *Jingsheng Ma, Heriot-Watt University, UK*

	BUFFET LUNCH
Session 3	**Chairman：Christoph Arns, Jianchao Cai**
14:30 - 15:00	Quantification of Multi-Scale Nature of the Porous Media Flows and Scale Up: Current Challenges *Birol Dindoruk, Shell International E&P Inc.,USA*
15:00 - 15:25	Finite analytic numerical method for fluid flows in heterogeneous porous media *Xiaohong Wang, University of Science & Technology of China, China*
15:25 – 15:50	Organic hosted and intergranular pore networks: Topography and Topology in Grains, Gaps &.Bubbles *Andrew Matthew, Carl Zeiss(Shanghai)Co., Ltd*
15:50 – 16:15	Multi-scale Pore Network Modeling of Gas Transport in Shale Gas Reservoirs *Wenhui Song, China University of Petroleum (East China), China*
16:15 - 16:45	**Tea break & Poster Discussion**
Session 4	**Chairman：Stefan Iglauer, Yingfang Zhou**
16:45 - 17:10	Progresses on research of digital core techniques by fractal geometry *Boming Yu , Huazhong University of Science and Technology, China*
17:10 - 17:35	A Data Enabled Model for Coupling Dual Porosity Flow with Free Flow *Craig C.Douglas, University of Wyoming, USA*
17:35 - 18:00	Flow simulation in unconventional reservoirs: from nano-scale to micro-scale *Yongfei Yang, China University of Petroleum (East China), China*
19:00	Welcome Dinner, Yanxi Hall, 1st Floor, Blue Horizon Hotel (蓝海一楼燕喜堂)

July 10th, 2018, Tuesday

Session 5	**Chairman：Arthur Moncorgé, Moran Wang**
08:30 - 09:00	The Impact of Fracture Roughness on Permeability-Stress Relationships *Roland Horne, Stanford University, USA*
09:00 - 09:25	On pore scale simulation of reactive flow *Oleg Iliev, Fraunhofer Institute for Industrial Mathematics ITWM, Germany*
09:25 - 09:50	Determination of fractal structure parameters and flow characteristics of porous media based on digital rock images *Jianchao Cai, China University of Geosciences (Wuhan),China*
09:50-10:15	Pore-scale Simulations Using Boltzmann Equation for Conventional and Unconventional Rock Samples *Jun Li, King Fahd University of Petroleum and Minerals, Saudi Arabia*
10:15 - 10:45	**Tea break & Poster Discussion**
Session 6	**Chairman：Jeff Gostick, Jingsheng Ma**
10:45 – 11:10	Integrating conventional and digital rock physics for advanced petrophysical cross-correlations *Christoph Arns, The University of New South Wales, Australia*
11:10 - 11:35	Several breakthroughs on pore network modelling for complex rocks *Zeyun Jiang, Heriot-Watt University, UK*
11:35 - 12:00	A diffusive interface method for two-phase flows with soluble surfactants *Guangpu Zhu, China University of Petroleum (East China), China*
	BUFFET LUNCH

Session 7	**Chairman：Craig C.Douglas, Boming Yu**
14:30 - 15:00	Reservoir Simulations and Molecular Simulations of Conventional and Unconventional Hydrocarbon Formations *Abbas Firoozabadi, Yale University, USA*
15:00 - 15:25	Coal microstructures and how they are affected by fluid-rock interactions *Stefan Iglauer, Edith Cowan University, Australia*
15:25 - 15:50	Numerical study of hydraulic fracturing in an anisotropic poroelastic medium via a hybrid EDFM-XFEM approach *Qingdong Zeng, China University of Petroleum (East China), China*
15:50 - 16:15	Pore scale visualisations of oil-water-additive interactions in reservoir-mimetic microfluidic *Hossein Hejazi, University of Calgary, Canada*
16:15 - 16:45	**Tea break & Poster Discussion**
Session 8	**Chairman：Zeyun Jiang, Xiaohong Wang**
16:45 - 17:10	Capillary Pressure and Dynamic effects in Mixed-wet Porous Media *Yingfang Zhou, Aberdeen University, UK*
17:10 - 17:35	Numerical Heterogeneous Core Modeling Based on CT-Images for Coreflooding Simulation *Yupeng Li, Beijing Research Center, EXPEC ARC, Saudi Aramco.*
17:35 - 18:00	Numerical simulation of the heat extraction in EGS with wellbore-reservoir coupling based on discrete fractures model *Xu Zhang, China University of Petroleum (East China), China*

特邀专家报告摘要

Presentation Abstract

Moran Wang

Tsinghua University

Title: Multiscale Simulation for Gas Flow in Micro/nano Pores of Deep-Seated Rocks

Abstract:

The gas flow mechanism in micro/nano pores of deep seated rocks is so important not only because shale gas in China is much deeper than that in USA, but also the deep seated gas resources may be the major contribution of unconventional clean energy resources. The big challenge comes from the coupling effects between Knudsen effects and non-ideal gas effects under in-situ conditions underground. In this paper, we establish a multiscale simulation method to couple the pore-scale simulation, capturing the Knudsen effects at micro/nano pores, with the field-scale modelling that can capture the non-ideal gas effects in large space. The inflow performance relationship and the decline curve analysis are well solved based on the multiscale simulation directly. Finally, we incorporate the influence of the elastic structural deformation in our modelling and propose the characteristic pressure model to calculate apparent permeability, which supports shale gas exploitation by providing theoretical analysis.

Arthur Moncorgé

Head of reservoir team in Geoscience Research Center at TOTAL E&P UK

Title: Stable and scalable sequential schemes for compositional simulation

Abstract:

The Fully Implicit (FI) method is widely used for general-purpose reservoir simulation. There has been a recent interest for new sequential-implicit (SI) and sequential-fully-implicit (SFI) schemes for compositional simulation. Sequential schemes solve the fully coupled system in two steps: (1) solve the pressure equation (flow problem); (2) solve the equations for the phase saturations and phase compositions (transport problem). During the second step, the pressure and the total-velocity fields are fixed. SI schemes only perform once the two-step sequence while SFI schemes repeat the two-step sequence until convergence to the FI solution. Fixing pressure and the total-velocity fields during the transport problem is introducing two types of ‘splitting errors’. We study these errors and their impact on the solutions. We then discuss strategies to control these errors in order to converge to the same solution as the FI method while keeping convergence properties comparable to those of the FI approach.

Kai Zhang

China University of Petroleum (East China)

Title: A Divide-and-Conquer Method for Large-Scale Water Flooding Optimization

Abstract:

In the past decades, a number of algorithms were proposed to solve production optimization problems. However, most of them suffer from the 'curse of the dimensionality' dramatically on large-scale problems. In view of this, a novel decomposition strategy is proposed to alleviate this issue. Firstly, it decomposes the original large-scale problem into several sub-problems efficiently according to the degree of interactions among decision variables. Then a sophisticated cooperative coevolution framework is employed to allocate computational resources among the sub-problems based on their dynamic contributions to the improvement of the objective value. Each sub-problem is solved by surrogate-assisted evolutionary algorithm in the above process. Finally, the optimal plan of the original water flooding optimization problem can be obtained by combining all sub-solutions. To show the efficacy of the proposed method, the experimental studies were conducted on a synthetic test function and a case study on Brugge field.

Jeff Gostick

University of Waterloo

Title: Multiphysics simulations of electrochemical devices using pore network modeling

Abstract:

Grid-scale energy storage and electrification of the transportation sector have been central issues in the transition to a renewable energy economy. The transport processes electrochemical devices such as fuel cells, electrolyzers, redox flow batteries, and solid-state secondary batters are complex, occurring in multiple phases (both solid and void), are highly coupled, and involve several length scales. In conjunction with this complexity, the physical structure of the electrodes plays an overwhelmingly large role in the cell performance. Transport in the various phases require that each form a highly connected percolation path, but this requirement is difficult to satisfy for all phases simultaneously. Pore-scale modeling of these systems is an excellent means to study transport and understand the impact of structure, but the computational resources required to do a true pore-scale model limit the size of domain to essentially a single scale. Pore network modeling, by abstracting the void (and solid) structure as a network of simple resistance, can reduce computational cost by several orders of magnitude while maintaining the essentials of the structure and the phase interactions. This

not only introduces the possibility of simulating meaningfully large domains (in some cases the entire device), but also enables inclusion of more complex physics. This talk will give an overview of recent advances made in incorporating multi-physics-based calculations into a pore network framework (OpenPNM) including transient phenomena, complex reaction kinetics, and including the solid phase transport via dual extraction of solid and void networks from tomography images.

Jingsheng Ma

Heriot-Watt University

Title: Digital Rock Physics for Petro-physical Analysis of Reservoir Rocks: Challenges and Opportunities

Abstract:

Digital Rock Physics (DRP) has emerged, from more than 20 years research, as a step-changing technology for complementing traditional petrophysical analysis at core plug and wellbore scales. DRP involves: 1) imaging rock samples; 2) image-based rock characterization and; 3) rock model reconstruction; 4) numerical simulation of physical processes; and 5) predication of effective rock properties. With the increasing capability of tomographic imaging and high-fidelity numerical modelling, DRP has been widely recognized and gradually adopted by oil and gas industry.

DRP offers possibilities to answer a much wider range of 'what-if' questions concerning any specific types of formations. Exemplar questions are those concerning the impacts of geological heterogeneity of formations, in terms of structures and lithological compositions and fluid in places, on hydrocarbon storage and transmission. Such questions cannot be addressed fully by examining measurements taken at in-situ and/or laboratory-controlled conditions alone but in complementation of simulating appropriate physicochemical processes on adjustable rock models in DRP. However, DRP faces great challenges in dealing with formations, such as shale, tight sandstone and carbonates, where geological heterogeneity is complex and gives rise to high-level uncertainty in digital rock characterization and in measurements.

Here the author highlights some recent progresses that have been made by the author and his associates in characterizing geological heterogeneity and quantifying their uncertainty on fluid flow in DRP. Examples include: mineral characterization of clastic rocks, characterization of cross-lamination in sandstones, multiscale DRP for shale gas flow, and wettability modelling on heterogeneous mineral surface.

Birol Dindoruk

Chief scientist of Shell International E&P Inc., NAE member

Title: Quantification of Multi-Scale Nature of the Porous Media Flows and Scale Up: Current Challenges

Abstract:

Fluid flow in porous media has attracted enormous attention from academia and industry as it has numerous applications, such as hydrocarbon production, shale gas recovery, CO_2 sequestration and ground water utilization, catalysis, etc. The fluid flow is governed by different phenomena at different scales ranging up to 12 orders of magnitude in dimension (nm to 100 m), from nanoscale (pore proximity), to microscale (wettability, contact angle, etc.), to core-scale (capillary pressure, relative permeability, etc.), and to reservoir-scale (geological heterogeneity, saturation distribution, vertical equilibrium, etc.).

It is still challenging to describe the representative fluid flow properties with quantification at a single or few scales. For example, some of the challenges include the difficulty of simulating the rock-fluid interactions at pore level, the limitation of current imaging technologies in terms of incapability of characterizing the sub-micron pores, and the improper use of core-flood results (e.g., relative permeability, capillary pressure) in reservoir simulations without careful upscaling. In addition, introduction of non-native fluids and depletion effects may further increase the complexities and the number of variables. This talk aims to highlight current state-of-the-art technologies for experimentation and simulation of multiphase fluid flow in porous media while highlighting some of the work that we have done, and to shed light on some of the common pitfalls and drawbacks.

Finally, this talk will also review some of the insights gained from previous studies by the industry regarding fluid behaviors that affect flow in reservoir rocks in terms of the following focus areas:

1) Rock/Fabric Structure
2) Fluids contained, multi-component, multi-phase
3) Containment (porous media)-Fluid interactions

First two of these areas (rock and fluid), when studied alone, can be evaluated in various ways while coupling dictated by their interactions makes the problem more complex and non-linear.

Xiaohong Wang

University of Science & Technology of China

Title: Finite Analytic Method for Fluid Flows in Heterogeneous Porous Media

Abstract:

Natural reservoirs exhibit wide permeability variations. It is a challenge and long-standing problem to numerically describe fluid flows in porous media with permeability variations. With the traditional numerical scheme, the refinement ratio for the grid cell needs to be increasing dramatically to get an accurate result. We find out that this difficulty is caused by the singularities due to the heterogeneity of permeability distribution. The finite analytic numerical scheme is proposed to solve the single-phase and multi-phase fluid flows in heterogeneous porous media to avoid the difficulty of the singularities. Numerical examples show, only with two or three subdivisions, the proposed numerical scheme can provide rather accurate solutions, both for permeability in the scalar and tensor form.

Andrew Matthew

Carl Zeiss(Shanghai)Co., Ltd

Title: Organic hosted and intergranular pore networks: Topography and Topology in Grains, Gaps &.Bubbles

Abstract:

In this study we compare and contrast two qualitatively different pore systems. Organic hosted porosity (existing on the nanometer scale and common in unconventional shale reservoirs) was imaged using 3D FIB-SEM techniques, and intergranular porosity (common in conventional sandstone reservoirs and existing on the micrometer scale) was imaged using micro-CT techniques. Scale independent connectivity metrics found the intergranular pore network to be much better connected than the organic hosted pore network, despite similar total porosity.

Wenhui Song

China University of Petroleum (East China)

Title: Multi-scale Pore Network Modeling of Gas Transport in Shale Gas Reservoirs

Abstract:

Due to the multi scale pore size distribution and hetergeneous pore structure, it is challenging to accurately predict fluid flow ability in shale porous media. Pore-scale imaging technique provides an feasible approach to understand shale pore structure. However, given the known heterogeneities and the nano-micro pore size, single resolution imaging is not adequate for representative characterization of pore structure. In this study, the image-based multiscale pore network model is constructed based on the proposed procedure and the impact of multi scale pore structure on fluid flow is analyzed in detail. 3D binary images are constructed by the Multiple-Point Statistics (MPS) method from a section of low-resolution SEM image which covers the large-scale structures and fine-scale SEM images with the same physical size at high resolution. The maximal ball fitting method is applied to extract large scale pore network and fine scale pore networks from the 3D binary images respectively. The multiscale pore network model is obtained by merging the large-scale pore network and fine-scale pore networks based on the spatial location of each pore and throat. Gas transport inside the pore network considers second order slip and real gas effect. Water flow considers boundary slip and viscosity change. Pore size distributions and fluid permeabilities are calculated based on the multiscale pore network model, large-scale pore network model and fine scale pore network model. The analysis results indicate that the existence of fine scale pores can enhance the fluid flow ability and accurate estimation of shale permeability must account for the multi-scale pore structure.

Boming Yu

Huazhong University of Science and Technology

Title: Progresses on research of digital core techniques by fractal geometry

Abstract:

As the development of computer added image process techniques and computational methods, particularly, since 21 century's the rapid development and wide application of digit technology have been received in the area of oil and gas reservoirs. This talk intends to briefly review on the applications of numerical core techniques in the area of oil and gas reservoirs, including the numerical image process techniques such as CT scanning, scanning electron microscope (SEM) technology, nuclear magnetic resonance and numerical simulations, as well as fractal technique and Mercury intrusion porosimetry, and their progresses. Finally, some comments will be made on the future research topics in this field.

Craig C.Douglas

University of Wyoming

Title: A Data Enabled Model for Coupling Dual Porosity Flow with Free Flow

Abstract:

In this talk, we provide a snapshot of a U.S. National Science Foundation funded project to create a working computational and data science model useful for reservoir simulation. This project carries out systematic research on the development, validation, numerical methods, data assimilation, and mathematical analysis for a dual-porosity-Navier-Stokes model. In many real world problems and industrial settings, the free flow of a liquid and the confined flow in a dual porosity media are often coupled together and significantly affected by each other. However, the existing Stokes-Darcy types of models cannot accurately describe this type of coupled problem since they only consider single porosity media. Therefore, with the support of external data, we follow the general framework of Stokes-Darcy model and dual-porosity model to develop a new coupled multi-physics multi-scale model and the corresponding numerical methods for accurately describing the coupling of the flow in dual porosity media and the free flow. The resulting coupled dual-porosity-Navier-Stokes model has higher fidelity than the Darcy, dual-porosity, Navier-Stokes, or Stokes-Darcy equations on their own. Furthermore, the field data provides the possibility to improve and demonstrate the accuracy of the model prediction through data assimilation.

Yongfei Yang

China University of Petroleum (East China)

Title: Flow simulation in unconventional reservoirs: from nano-scale to micro-scale

Abstract:

With the growing demanding of energy and gradual dwindling of conventional energy, the energy extracting focus is shifted to unconventional energy. This study is performed to investigate the flow mechanisms of unconventional oil and gas. First, by molecular simulations, the adsorption behaviors of methane inside nano-organic slits as well as the influencing factors are studied and the adsorption isotherms are obtained. Since water is ubiquitous in unconventional reservoirs, the occurrence behaviors of methane near organic solids and the slip of oil inside nano-organic slits in aqueous environments are both investigated. Second, coupled with the results of molecular simulations, the lattice Boltzmann method is utilized to study unconventional gas and oil flow characteristics at micro-scale. By introducing the interaction force between the gas particles and solid wall which is determined by molecular simulations,

shale gas production is studied considering the effect of adsorption/desorption. In addition, by introducing the effective viscosity and slip length which are also obtained by molecular simulations, oil and water flow is examined considering the nano-scale effects.

Roland N. Horne

Stanford University, NAE member

Title: The Impact of Fracture Roughness on Permeability-Stress Relationships

Abstract:

For conventional and enhanced geothermal reservoirs, faults and fractures are the main conduits for flow. In geomechanical simulations, empirical models are typically used to calculate the changes in fracture permeability due to stress application. However, determining the appropriate model parameters is often problematic due to the lack of available data and the difficulty of performing shear experiments. The displacement discontinuity boundary element method with integrated complementarity (DDM) is an advantageous alternative approach because it is a consistent physical model that simulates fracture permeability evolution under changing stress conditions.

In this study, the DDM model was used to investigate the changes in permeability due to applied stress conditions for rough fractures. Fracture aperture maps for the different stress conditions were generated using the DDM model. Afterwards, a local cubic law model was used to calculate the fracture permeability. Results showed that the roughness of the fracture surface created stress interactions that led to local opening in the absence of a fluid within the fracture. The rough fracture surface also created heterogeneous fracture aperture and slip distributions. Overall, the fracture permeability and average slip increased with the shear stress magnitude and decreased with the normal stress magnitude. Moreover, it was demonstrated that the fracture permeability was higher in the direction perpendicular to the applied shear stress direction compared to the parallel direction.

Jianchao Cai

China University of Geosciences (Wuhan)

Title: Determination of fractal structure parameters and flow characteristics of porous media based on digital rock images

Abstract:

The study of seepage characteristics is one of hot topic in the vigorous development of unconventional oil and gas resources. A large number of studies have shown that the seepage flow characteristics are highly related to the microscopic structure of porous media. Therefore,

how to accurately character and quantify microscopic structure of porous media is a general and critical question. Fractal geometry is a very popular tool for microstructure analysis of porous media images, and it includes several parameters to characterize microscopic structure of reservoirs. Based on the fractal theory, there are three fractal structural parameters can be applied to characterize the microstructure of reservoir cores: 1) Fractal dimension characterizes complexity, 2) Lacunarity characterizes heterogeneity, and 3) Succolarity characterizes anisotropy. In this study, three-dimensional digital samples of sandstone reservoirs are used to calculate permeability and fractal structure parameters. Then the fractal structure parameters are used to quantitatively characterize the changes of core structure and analyze their effect on permeability. We find that only use pore size distribution or fractal dimension to analyze complex microscopic structure and flow characteristics are not exact enough, using the three parameters (fractal dimension, lacunarity and succolarity) can have a better explanation of some complicated the phenomenon in porous media, such as heterogeneous structure and anisotropic physical properties.

Jun Li

King Fahd University of Petroleum and Minerals

Title: Pore-scale Simulations Using Boltzmann Equation for Conventional and Unconventional Rock Samples

Abstract:

For the conventional rock sample, the permeability (i.e., absolute permeability) is a property of rock sample. The computations of absolute permeability with experimental validations will be presented and the possibly unintentional discrepancy will be discussed to develop an appropriate procedure for the analyses of digital rock physics. For the unconventional study, the permeability is not a constant and increases with the decrease of pore pressure due to high Knudsen (Kn) number, which is called the Klinkenberg slippage phenomenon. This dominant mechanism can be modeled by the Boltzmann equation and the challenging task is to accurately and efficiently solve the complicated integro-differential Boltzmann equation at low flow speed in an irregular pore space. The well-developed and widely recognized numerical method is the direct simulation Monte Carlo (DSMC) method but it becomes very time-consuming at low speed due to stochastic noise. The efficient DSBGK method was proposed recently by the speaker and successfully applied to study the permeability of shale gas in real rock samples over a wide range of production pressure having a wide range of Kn consequently. The kinetic theory based on the Boltzmann equation and several relevant numerical methods will be introduced. Then, the numerical results by the DSBGK method will be presented to show its accuracy, efficiency, and applicability in real problems with hundreds-cubed voxels.

Christoph Arns
The University of New South Wales

Title: Integrating conventional and digital rock physics for advanced petrophysical cross-correlations

Abstract:

Determining underlying mechanisms of petrophysical cross-correlations as function of stress is a major task in rock physics. In recent years the development of micro Xray-CT approaches to petrophysical property prediction has made large advances. The technique requires balancing field of view (FOV), to achieve a representative volume and reduce boundary effects, with resolution required to accurately solve for physical properties numerically. In this talk I will introduce techniques for the regional analysis of field solutions derived numerically from tomographic images. Regional analysis techniques allow correcting experiments for boundary errors as well as embedding a natural upscaling mechanism through rock-typing procedures. Extensions to NMR methods for downhole applications and to analyse rock-type boundaries are discussed.

Zeyun Jiang
Heriot-Watt University

Title: Several breakthroughs on pore network modelling for complex rocks

Abstract:

It is important to characterise the heterogeneity in carbonate rocks at the pore-scale, due to the fact that the geometry and topology of the pore structures can strongly affect multiphase flow at macroscopic scale. Carbonate rocks contain a wide range of pore sizes, abundant fossil components (e.g. Nummulites) and a network of micro-fractures, which make it extremely difficult to calculate petrophysical properties and consequent flow outcomes. The three-dimensional (3D) digital representations of pore structures of interest and fluid distributions, which have been verified by many imaging techniques, such as X-ray computed micro-tomography (μCT) and scanning electron microscopy (SEM), is the starting point for digital rock physics/analysis and leads to many successful applications. However, many important pore-scale features (e.g. cross-scale connectivity, pore-fracture interaction, Nummulites-pore exchange) cannot be captured accurately due to the volume-resolution trade-off for big samples of elementary representative volume. The multi-scale network (Jiang et al., 2013) provides an effective means to represent two or more length-scale pore structures but suffers from a lack of information on accurate cross-scale connectivity, to which we introduce an patch-based

optimization method (Huang et al., 2018 Interpore USA, 2018) to reconstruct 3D models from 2D training images that are selected to have local cross-scale pore-structures of both micro- and macro-pores. To include Nummulites and pores simultaneously, we present methods (Jiang et al, 2017; Jiang et al., 2018; Li et al., 2018) to directly generate network for multi-phase flow simulation, avoiding models that are required to have components or microfractures of 10s mm and pores of half-μm. Consequently both could result in massively large pore networks (e.g. 10s millions of network elements), being unable to run any convenient flow simulators, which are significantly improved by our newly developed algorithm (Petroveskyy et al., Interpore USA 2018), and called dynamic phase connectivity. Comprehensive tests have been carried out and the results of our flow simulations on generated networks highlight the requirement for correct determination of the dominant pore scales (one plus of nm, μ m, mm, cm), the cross-scale connections and the spatial correlation, Nummulites-pore and microfracture-pore connectivity.

Guangpu Zhu

China University of Petroleum (East China)

Title: A diffusive interface method for two-phase flows with soluble surfactants

Abstract:

In this study, we develop a linear, energy stable scheme for a hydrodynamics coupled phase-field surfactant model. The nonlinearly coupled model consists of two Cahn-Hilliard type equations and incompressible Navier-Stokes equations with variable densities and viscosities. The Invariant Energy Quadratization (IEQ) approach is introduced to transform nonlinear potentials into quadratic forms, which provides fundamental support for linearization method, and a splitting method based on pressure stabilization is used to solve the Navier-Stokes equations. The proposed scheme is extremely efficient and easy-to-implement. The computations of phase variables are decoupled form velocity and pressure at each time step. Moreover, we rigorously prove the unconditional energy stability of the semi-implicit scheme. An efficient finite volume method on staggered grids is used for the spatial discretization. Numerical results in both two and three dimensions are obtained, which demonstrate that the constructed scheme is accurate, efficient and energy stable. Using our scheme, we study the effect of surfactants on droplet deformation and merging. A more prolate profile of droplet is observed under the higher surfactant bulk concentration. Increases in surface Péclet number and surfactant bulk concentration can enhance the non-uniformity of surfactant distribution along the interface, which will arise the Marangoni force. The Marangoni force acts as an additional repulsive force to delay the droplet merging.

Abbas Firoozabadi

Yale University, NAE member

Title: Reservoir Simulations and Molecular Simulations of Conventional and Unconventional Hydrocarbon Formations

Abstract:

This presentation is divided into two parts. In the first part, higher-order simulation of fractured reservoirs in 2-D and 3-D unstructured gridding is presented. We will demonstrate that a combination of physical concepts and higher-order methods will allow highly efficient and accurate reservoir simulation with any geometry and complexity of fractures. The numerical dispersion is lower than all published methods. The second part covers fluid-in-place and flow in shale permeable media. There is currently no instrument to measure adsorption and fluid-in-place. Only excess adsorption can be measured at high pressures. Molecular and atomistic simulations facilitate the understanding at the atomic and molecular scales and they can be used to interpret the shale laboratory measurements. A complexity in shale formations is that the organic part may not be a crystal. In molecular modeling for kerogen we may need to have all the atoms in a kerogen molecule to be flexible. In this presentation I will first present our recent measurements both in adsorption and in flow and then discuss our atomistic model with flexible atom positions in the kerogen medium of the shale.

Stefan Iglauer

Edith Cowan University

Title: Coal microstructures and how they are affected by fluid-rock interactions

Abstract:

Coal is a major fossil fuel resource, and relatively recently natural gas production from unmineable coal seams (coal bed methane recovery) has seen a dramatic rise. Such gas production can be further enhanced by various techniques, of which fluid injection is the most common one (so called enhanced coal-bed methane recovery). Such gas production, however, frequently declines rapidly in individual production wells, and it is thus important to understand the detailed mechanisms of the methane recovery to avoid such an unwanted scenario. One key aspect in this context is the (very complex) microstructure of coal, and how it is affected by production mechanisms. Thus multiple engineering situations were tested in laboratory experiments, and associated coal microstructures and their changes were imaged at high resolution in 3D via x-ray micro-computed tomography. The results of these experiments are presented and their implications in terms of coal bed methane recovery are discussed.

Qingdong Zeng

China University of Petroleum (East China)

Title: Numerical study of hydraulic fracturing in an anisotropic poroelastic medium via a hybrid EDFM-XFEM approach

Abstract:

In this study, we investigate the effects of poroelastic properties and permeability on hydraulic fracturing in an anisotropic medium. A hybrid approach combining the EDFM (embedded discrete fracture model) and XFEM (extended finite element method) is proposed. Fractures are embedded into a nonconforming grid used to determine the fluid flow in a porous matrix by the mimetic finite difference method, accounting for an anisotropic permeability tensor. The stress-strain problem is solved by the extended finite element method with the same grid. The fixed-stress split method is adopted, and the fluid flow and rock deformation as well as the fracture propagation are iteratively coupled. The proposed approach is validated against the analytical solutions for Mandel's problem and the KDG model. A series of calculations are performed, and the obtained results are analyzed to investigate the effects of the anisotropy of permeability, that of the elastic modulus and Biot's coefficient on the hydraulic fracturing process. Results indicate that the anisotropy of permeability has little effect on the fracture propagation direction, while it significantly affects the fracture propagation velocity. The anisotropy of the elastic modulus has a major effect on the propagation direction of a hydraulic fracture. The final propagation direction will be approximately parallel to the anisotropy angle of formation.

Hossein Hejazi

University of Calgary

Title: Pore scale visualisations of oil-water-additive interactions in reservoir-mimetic microfluidic devices

Abstract:

Chemicals, solvents (light hydrocarbons, CO2) and surfactants coffer key means to achieve improved oil recovery processes with reduced energy demand, GHG emissions and water use. However, chemical choice, injection pressure, chemical content, and timing remain to be optimized. More fundamentally and in the case of hybrid thermal recovery methods, the mechanisms of combined heat and solvent transport, multiphase flow, and emulsion formation require further investigation within the porous reservoir rocks. In the case of unconventional tight reservoirs, surfactant and emulsion flooding can be promising. However, the fate of

emulsion stability and flows in micron size pores of rock needs to be resolved. In this talk, we couple microfluidics and confocal microscopy to provide rapid screening and 3D visualization capabilities to analyze displacement processes of trapped oils in pore geometries that have the same characteristics of reservoir rock samples.

We fabricate microfluidic devices based on the pore structures of subsurface rocks. The internal surfaces of the microchannels are coated with geomaterials, e.g. clay particles, thus mimicking the surface chemistry of real reservoir rocks. The reservoir-mimetic micro-reservoirs are used in 3D visualization experiments to disclose the interfacial and intricate pore-scale interplays between multiphase fluid transport and this interplays' impacts on emulsions and associated enablement of oil drainage. We provide new insights on the dynamics of heavy oil mobilization in the presence of additives in the form of surfactants and nanoparticles. Understanding the physical mechanisms involved in pore scale multiphase flows is critical to many technological applications including advancement in in-situ recovery of oil and gas resources.

We investigate and screen different experimental conditions and chemical precursors to find the most efficient and affordable synthesis route applicable to large field scales. The developed microfluidic device is demonstrated to be a powerful mimetic model for the real-time visualization of the chemical/thermal-based oil recovery processes in micro/nano scales. Considering the time-consuming and expensive nature of coreflood experiments, this micro-scale approach provides an attractive model for rapid and low-cost EOR screening studies. The proposed platform provides an excellent context for developing new techniques, approaches, and understandings of fundamental problems related to the subsurface flows.

Yingfang Zhou

Aberdeen University

Title: Capillary Pressure and Dynamic effects in Mixed-wet Porous Media

Abstract:

Wettability plays a critical role in multiphase flow in porous media, because it affects the pore scale displacement mechanisms through the way it controls fluids configuration and distribution. Due to the complexity of fluids and rock components and hydrocarbon migration in the reservoir, amount of the reservoir rocks are mixed-wet. Besides capillary force, viscous force also acting as a main force to determine the fluid configurations, and thus significant dynamic effects could appear in the capillary pressure/saturation relation.

In this talk, we first present the static capillary pressure curve along with its fluid configuration in mixed-wet pore space that extracted directly from 2D rock images. The impact of wettability and saturation history during primary drainage on capillary pressure and fluid configuration are discussed extensively. The dynamic capillary pressure is calculated with

volume-averaged phase pressures, and dynamic capillary coefficients are obtained by computing the time derivative of saturation and the difference between the dynamic and static capillary pressure. The dynamic capillary coefficient increases with decreasing water saturation at water-wet conditions, whereas, for mixed- to oil-wet conditions, it increases with increasing water saturation. The imbibition simulations performed at mixed- to oil-wet conditions also indicate that the dynamic capillary coefficient increases with decreasing initial water saturation.

The proposed modeling procedure provides insights into the extent of dynamic effects in capillary pressure curves for realistic mixed-wet pore spaces, which could contribute to the improved interpretation of core-scale experiments.

Yupeng Li

Beijing Research Center, EXPEC ARC, Saudi Aramco.

Title: Numerical Heterogeneous Core Modeling Based on CT-Images for Coreflooding Simulation

Abstract:

This study presents a methodology development of numerical reconstruction of carbonate core plugs using CT-images for coreflooding simulation. The objective is to build up the numerical core model with heterogeneous feature for simulating chemical flooding process. The core model constructed directly from the originally fine resolution CT-images would bring computing CPU challenges while conducting numerical simulations in the fine scale numerical core plug model. In this work, the numerical core model was generated using a coarse grid of the original image resolution considering the computing constraints and representative heterogeneity requirements. The porosity of the numerical core model was reconstructed based on the image segmentation method. The effective medium approximation (EMA) method was used to compute absolute permeability in the coarse grid and the effective value of the entire model was estimated by the flow-based method. The numerical core model matched well with the physical model from lab measurements. Core-scale waterflooding and polymer flooding was simulated using MRST module in Matlab to demonstrate the polymer effect on oil displacement in the constructed heterogeneous core model.

Xu Zhang

China University of Petroleum (East China)

Title: Numerical simulation of the heat extraction in EGS with wellbore-reservoir coupling based on discrete fractures model

Abstract:

Wellbores in enhanced geothermal system provide large heat exchange surfaces between circulating fluids and enclosing formation, and successful management of subsurface geothermal resources involves a system comprising wellbores, a hot artificial reservoir and a surrounding formation. A coupled wellbore-reservoir 3D model considering discrete fractures network is demonstrated to investigate the heat extraction performance of EGS. The proposed model is validated by comparing with several analytical solutions and is capable of modeling not only the thermos-flow in the reservoir and wellbores, but also the heat conduction from rocks surrounding hot reservoir. The results indicate that the heat interaction between water and formation enclosing wellbores affects the circulation temperature significantly at low flow rate, while for large flow rate, the friction heat generated in the wells is the dominant influence factor of fluid temperature. The overall compensation heat from the surrounding rocks is positive and comprise a significant proportion of accumulative extraction heat. The main parameters controlling the temperature profile along wellbore and improving the heat extraction performance of EGS are also investigated by sensitivity analysis. This study provides a better insight of realizing the importance of wellbore and surrounding formation heat transfer and improving heat extraction performance.

校园全貌图

UPC Campus View

乘车路线

1）青岛火车站→蓝海金港大饭店

全程约 25km，乘坐公交车 40 分钟左右可到达；

具体路线：火车到达后从火车站“东出站口”出站，往右前方行走约 500m，至肯德基餐厅对面的公交站牌，乘坐“隧道 5、隧道 6、隧道 7、隧道 8”等四路公交车均可，到“石油大学站”下车，向西步行 500 米，从学校南门进入校园，然后往北走至学校北门，东侧即为“蓝海金港大饭店”。

2）青岛机场→莫泰酒店→蓝海金港大饭店

全程约 60km，乘坐机场大巴（票价 40 元）2 小时左右可到达莫泰酒店（距中国石油大学约 3.5 公里），之后可乘坐 22 路公交至石油大学北门下车，马路对面即为“蓝海金港大饭店”；

机场大巴时间表如下：

发车时刻	08:30	9:30	10:30	11:30	13:30	14:30
	15:30	16:30	17:30	18:30	19:30	20:00
问询电话	机场 24 小时热线：96567，莫泰酒店：0532-86989888 蓝海金港大饭店：0532-86986666					

此外，莫泰酒店→青岛机场时间表如下：

发车时刻	05:30	06:30	07:30	09:30	11:30	12:30
	13:30	15:30	16:30	17:30	18:00	19:30
问询电话	机场 24 小时热线：96567，莫泰酒店：0532-86989888 蓝海金港大饭店：0532-86986666					

Venue and Route

1 Venue---Accommodation

The conference will be held at Yifu conference room of the Qingdao Campus, China University of Petroleum (East China). Blue Horizon Hotel, which is near to the university, will be available for the conference registration and accommodation. Free breakfast will be provided by the hotel after accommodation.

Blue Horizon Hotel

►**Address:** 66# Changjiang West Road, Economic &Technical Development Zone, Qingdao, Shandong Province, China 266580.

►**Tel:** +86-0532-86986666

2 Route --- Accommodation

QingdaoLiutingAirport ------ Mo Tai Hotel-------Blue Horizon Hotel

Vehicle: A daily coach bus (ticket fees 40 RMB) between the airport and Mo Tai hotel will be available and the detail information is shown as follows. Then take No.22 bus to the north of China University of Petroleum, the Blue Horizon Hotel is on the other side of the road(about 3.5 kilometers). If you take taxi from airport to Blue Horizon Hotel, it will take about 1.5 hours.

Qingdao Airport→Mo Tai Hotel

Time	08:30	9:30	10:30	11:30	13:30	14:30
	15:30	16:30	17:30	18:30	19:30	20:00
Inquiries	Airport: 96567. Mo Tai Hotel: 0532-86989888 Blue Horizon Hotel: 86981577					

Mo Tai Hotel →Qingdao Airport

Time	05:30	06:30	07:30	09:30	11:30	12:30
	13:30	15:30	16:30	17:30	18:00	19:30
Inquiries	Airport: 96567. Mo Tai Hotel: 0532-86989888 Blue Horizon Hotel: 86981577					

会议记录

Conference Notes

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