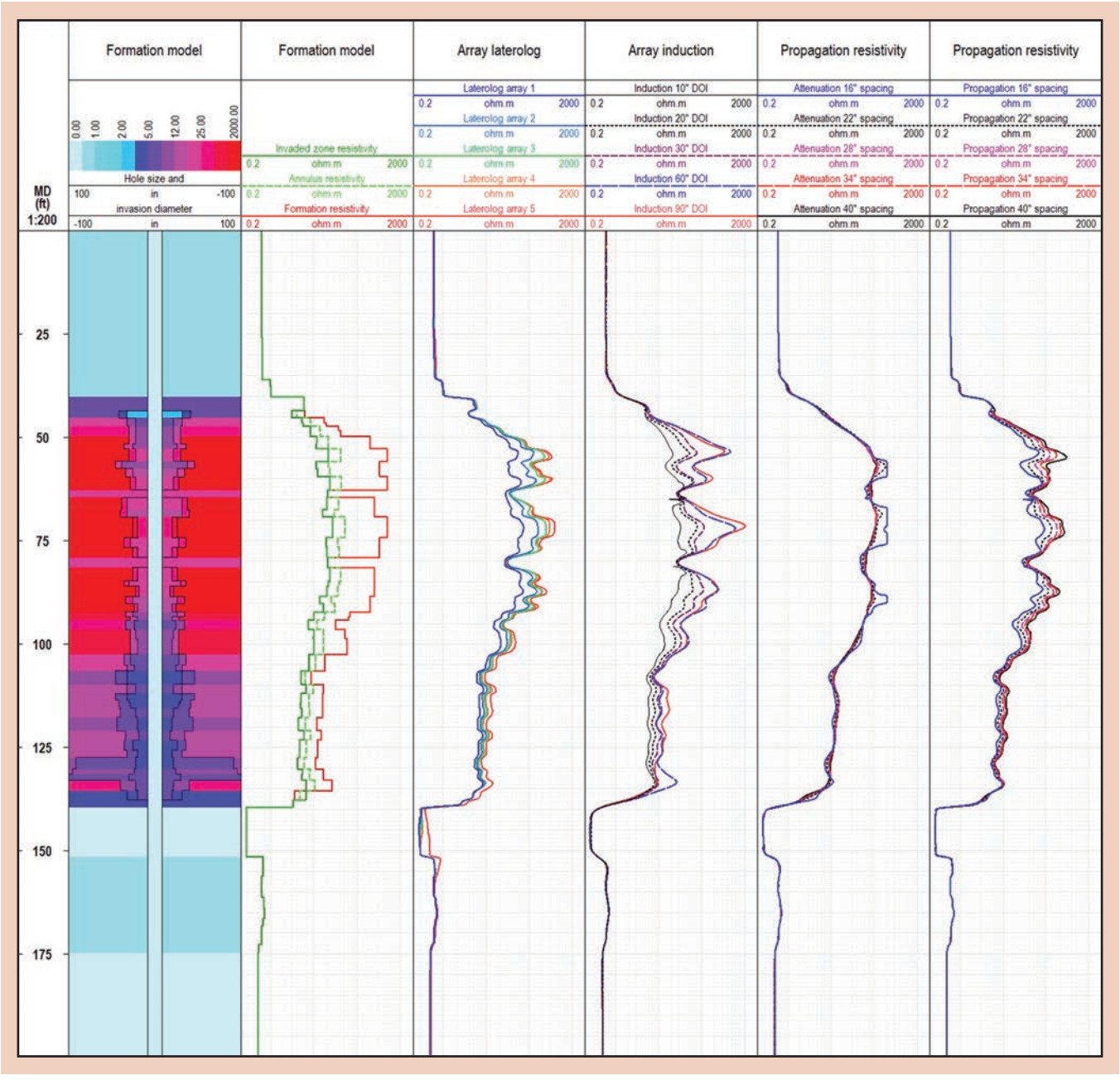
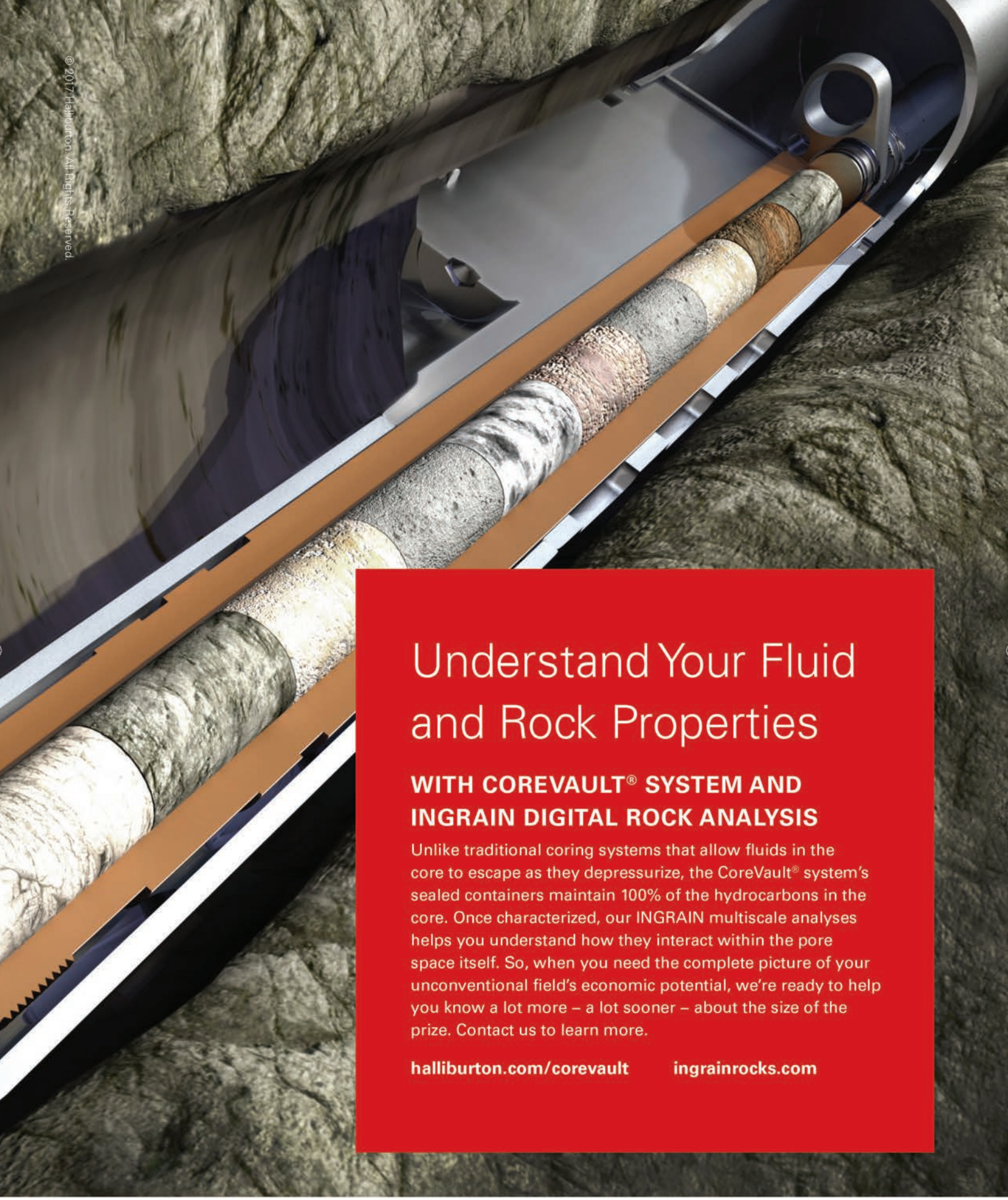
ISSUE 6 | VOL 2 | NOVEMBER 2019

THE SPWLA TODAY NEWSLETTER



SOCIETY OF PETROPHYSICISTS AND WELL LOG ANALYSTS



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Notice: Articles published in SPWLA Today are not subject to formal peer review but are subject to editorial review and are verified for technical consistency and relevance.

CALENDAR OF EVENTS

November 1–2, 2019

Workshop on "Porous Media: Structure, Flow, and Dynamics"
Hosted By: The Boston Chapter of SPWLA
Cambridge, MA, USA
www.spwla.org

March 1–5, 2020

SPWLA Bangkok–Asia Pacific Regional Conference
Theme: "Petrophysics: From Exploration to Brownfield—The Impact of Formation Evaluation on Oil and Gas Field Development Decisions"
Bangkok, Thailand
www.spwla.org

June 20–24, 2020

SPWLA 61st Annual Symposium
Banff, Alberta, Canada
www.spwla.org

About the Cover

Modeled resistivity tool response to the Gulf Coast Invasion formation model (Anderson, B.I., and Barber, T.D., 1997, Induction Logging Manual, Schlumberger). As Barbara Anderson explains in her column in this issue of SPWLA Today, resistivity modeling such as this is a valuable tool for understanding tool response and solving complex interpretation problems.

Jesús M. Salazar
2019–2020 SPWLA President
salazarjm@utexas.edu

Fellow SPWLA members, this will be the last issue of the SPWLA Today newsletter in 2019. It will also be my last column of the year, and before I start updating you on what's going on in our society I'd like to wish everyone a happy holiday season. Please enjoy in a healthy way, spend quality time with your family and friends, travel to amazing places, but please don't eat too much or you'll pay the price early next year. We are all super busy working on projects in our day jobs, but remember there's only one life that we deserve to live it to the fullest.

The survey to vote on changes to the Bylaws and Articles of Incorporations (BLAI) closed on September 19. A total of 651 members cast ballots, which is the usual number of voters we have during the annual elections (600 to 700). The membership has overwhelmingly voted to pass all the proposed changes with approvals that ranged between 84 and 95%, way above the minimum of 75% of the total number of ballots required to pass the proposed changes to BLAI. I hope everyone had the chance to see the email showing the side-by-side comparison of the previous articles and sections against the changes we proposed, with the voting results for and against such changes. The new BLAI are far from perfect, but the membership agreed that a few changes were warranted. Let's give the new system a try for the next election and awards period and see what happens. There's always room for improvement, and I'll do my best to listen to the membership and make additional changes before my term is over or I would also set the table for the next President and his BOD.

These changes are effective immediately. However, anyone in the current board who has been serving for more than five consecutive years will be able to finish their term and if they want to come back to the board, they may run for President-Elect only. Speaking of which, Past President Zach Liu sent an expression of interest (EOI) request for the upcoming elections of the new Board. Similar to last year, people are able to self-nominate. With the new BLAI there are a few requirements for critical positions, which are stated in the EOI. If you are passionate about SPWLA and have been already involved in local chapters, conference, or with our publications, please contact Zach and add your name as a potential nominee.

I had couple of busy weeks since my last column. I visited two chapters and also a sister organization. At every meeting I gave a presentation about the SPWLA and on technical topics about petrophysics. In late August, I visited the Houston Chapter of EAGE, thanks to an invitation extended by Dr. Mariela Araujo, who organizes their monthly seminar. It was a great opportunity to talk about the SPWLA and unconventional petrophysics to a mixed audience of geoscientists and engineers.

At the beginning of September, I traveled to the American West, Lubbock, Texas, to speak at the Texas Tech University SPWLA Student Chapter. I had two incredible hosts, current and past chapter presidents Rushil Pandya and Ibe Ezisi, respectively. They gave me a tour of the Petroleum Engineering Department and introduced me to faculty and students. They wanted me to talk about the operations within the SPWLA and I gave him a talk called, "The SPWLA From the Inside." It was an extended and detailed version of my five slides about SPWLA that I usually present during my visits to chapters. The Texas Tech Student Chapter

Fig. 1—Texas Tech University faculty and students, famous Professor George B. Asquith is to my right and chapter President Rushil Pandya is sitting in the front.

is a very dynamic group, in their meetings they have attendees from various engineering and geoscience majors, not only petroleum engineering, but also mechanical and civil engineering. They've been raising funds very efficiently via training offered by volunteers and friends of the University. They're in a position to invite non-Distinguished Speakers and partially cover their expenses. The university has also increased their annuity to the chapter year after year. Figure 1 shows some of the attendees to my presentation at TTU.

I want to thank the Japan Formation Evaluation Society (JFES, a chapter of SPWLA) for inviting me to be their keynote speaker in their annual symposium in Chiba, Japan (about one hour south of Tokyo). As you may know, it's a tradition that the SPWLA President-Elect attends to this conference. Last year, I had a scheduling conflict and was not able to attend, but I was lucky to attend this year as President. I cannot say enough of the graciousness and kindness of JFES' folks, especially my hosts Yuki Maehara, Tetsuya Yamamoto, and chapter president Professor Masanori Kurihara. They were very happy to have someone from the board visiting and they want to be more involved with us, one of his board members is now part of the technical committee for the 2020 Symposium. They feel proud to be now officially linked to the SPWLA since they signed the Charter Agreement in 2017. See Fig. 2 for a group picture during the conference.

The theme of the JFES conference was "Low Carbon Emission Energy." So, I tailored my keynote to the theme with the title, "New Trends in Energy Resources, 2020 and Beyond: Petrophysicists are Already Playing a Role." I found the conference quite interesting, covering technical problems on new technologies in petrophysics, thermal energy, and carbon capture use and storage (CCUS). During my keynote, I spoke about the fear that many professionals in oil and gas may have on becoming obsolete in the future. Working in the oil and gas exploration and production industry we wonder, what will be the energy of the future? Are renewables replacing fossil fuels? What will be the role of petrophysicist in the next 20 to 40 years? All those are valid questions and we need to guide the younger generations to making the right decision for themselves and for a better world. Let's keep in mind that our industry has become cleaner and safer than it was a few decades ago. Since 1990, renewable energy resources have grown at an average annual rate of 2.0%. However, fossil fluids, specially oil and gas are still the leading source of world energy and it'll remain like that in the next 20 to 40 years. Let's say that oil and gas is the energy of the masses. There are still plenty of opportunities for subsurface people like us to keep us working on interesting petrophysical problems for more decades to come. We need to find ways to make it cheaper and environmentally conscious.

Fig. 2—Japan FES Symposium attendees. I am in the first row surrounded by Professor Masanori Kurihara to my right and my former mentor during an internship with Oxy and Austin Chapter founder Shinichi Sakurai. It was great to see Shin after so many years. Photo courtesy of JFES.

From the President

Recently, I have been working with Latin American Director Nadege Bize-Forest to engage more people from the region in their local SPWLA chapters. This includes conversations with contacts in Colombia, Mexico, and Argentina. Mexican Chapter President Hugo Hernandez Espinosa envisages a potential growth in the Mexico Chapter that will require more volunteers. We have received expression of interest from petrophysicists in Suriname to start a local chapter and from Venezuela to revive their chapter.

Along with VP Education Katerina Yared, we have officially established the social media committee to keep you informed of everything happening around the world in the SPWLA. We continue working with the CWLS to organize an outstanding 61st Annual Logging Symposium in Banff, Alberta, Canada. I hope you had time to submit an abstract to present your research and innovation projects. You should be hearing from the VP Technology Michael O'Keefe before year end whether your proposal was accepted, it's always very competitive. But regardless of the outcome, make plans to come to Banff, and just in case, start prepping your hiking and fishing gear too, if you fancy to enjoy a couple of extra days in the Canadian Rockies.

Stay connected my friends,
Jesús M. Salazar, Ph.D.
linkedin.com/in/spwla-socialmedia-454464105
Instagram @chichosalazarpetro

James Hemingway
2019–2020 SPWLA
President-Elect

Hello fellow Petrophysicists,

This is a rather slow time for me, not so for many others. I've been watching the abstracts trickle in and so far, we seem to be on par with previous years, rather slow at first with a burst of submissions during the last week.

We are currently soliciting proposals to host the 2021 symposium. So far, two locations have expressed interested in hosting, and possibly, there will be more. We would like to make a decision on the 2021 Symposium location by early December. Although the 2020 symposium is international-ish we should consider a US location for 2021 but something outside the US would be considered too.

As in my previous letters, I continue to promote and hope for new and innovative techniques that will provide information needed to make better completion decisions. Our ability to calculate water saturation based on conventional techniques is reaching a useful limit, especially in unconventional reservoirs. We need to strive to use new measurements and techniques to make better completion decisions. The ultimate goal that we should strive for is lower completion costs along with higher production. I know that sounds like 7th grade economics, "spend less, make more," but a focus on new measurements should make this possible. Although we may need to work together to promote petrophysics as an important integral part of the industry's workflow.

I'm looking forward to seeing everyone in Banff.

Best Regards,
James Hemingway
President-Elect

Michael O'Keefe
2019–2020 VP Technology

Greetings to All,

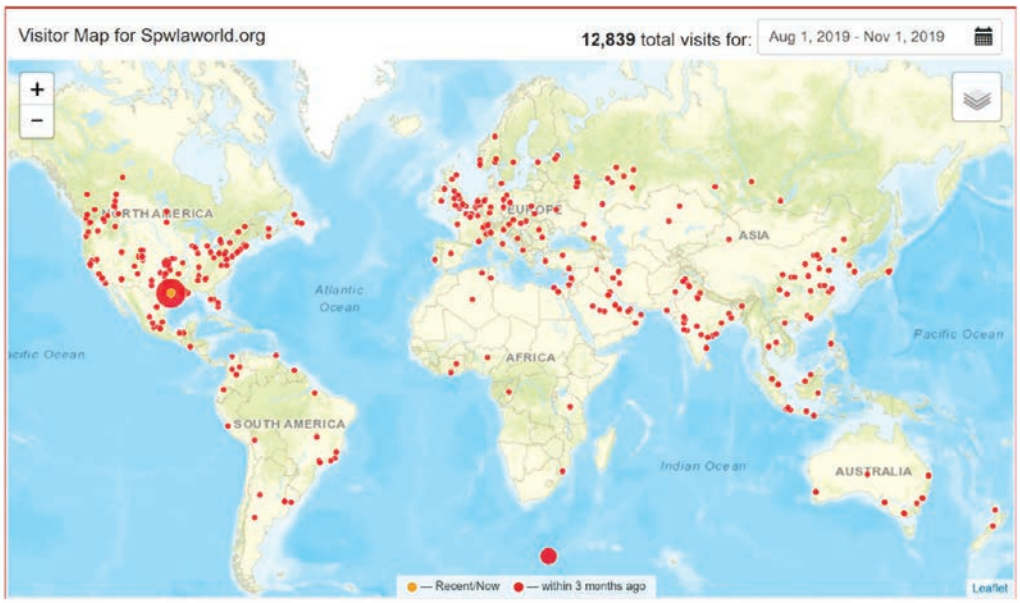
The abstract submission period for the 61st Annual Symposium in Banff is now closed.

A big thank you to all who took the opportunity to get involved and vie for a position at this premier event for log analysts. I am proud to report that we had a total of 384 abstracts submitted!

These were grouped into nine categories, with the largest four being Unconventional Reservoirs, Case Studies, Formation Evaluation in Conventional Reservoirs, and (predictably) Advances in Machine Learning.

It is not a straightforward endeavor to compose a good and worthy abstract! Reviewing your best projects over the past year to distill into a couple of paragraphs that will define succinctly what you and your colleagues have been working on, obtaining permission and buy-in from partners, transposing into a readable English prose that would put Shakespeare to shame, jumping through legal hoops, and convincing your manager that Banff is seriously all about your career progression and not just home to some excellent hiking trails. All done to place your stamp on the world, and own an original document whose subject matter you care passionately about.

The new website for online entry at www.spwlaworld.org proved much more streamlined than in previous years, and allowed full editing right up until the cutoff date last Sunday. Although a few were caught out trying to enter their SPWLA login credentials instead of creating a new account, Stephanie Turner was on hand to help out and smooth the process for all. Next year we shall optimize the submission process further, and improve clarity in the instructions. Below, I include an image showing geographical spread of the more than 12,000 visitors to our webpage since abstract submission was first opened. It seems a lot of editing has been taking place ☺



Now the real work begins for all our committed volunteers on the 2019–2020 Technical Committee (TC)!

We kick the process into motion to review and rank all the submissions. First, every abstract will be completely anonymized by removing the names of authors and coauthors, and company or university affiliations, etc. Second, each member of the TC will review 100 anonymous abstracts, based largely upon their area of expertise, and asked to rank them in simple numerical order from 1 to 100. Using this pure ranking system (rather than scoring each individually) will remove any deviation bias from those who tend to score higher or lower overall. Third, each abstract will receive a minimum of 12 rankings and I will take the mean of these rankings to compute the final TC score. I have increased the number of TC members this year, to increase the number of reviewers per abstract, resulting in a statistically fairer scoring system, which in turn, should deliver a very solid technical program for Banff.

The results will be sent to authors in December, and the accepted abstracts will be published on our website in Q1 2020. Please bear in mind that with this Symposium being so popular, only a limited number of abstracts will be able to make it through the peer-ranking process successfully.

Workshops

I am soliciting organizers for the 1- or 2-day Short Courses and Workshops that will be held prior to the start of the Symposium on Saturday and Sunday (June 20–21). These can have several instructors. If you are willing and able to run such an event, please contact me separately by email to vp-technology@spwla.org .

Thank you all for supporting our Society, and as this is the last Newsletter for this year, I wish you and your families all the best over the coming holiday period.

Best Regards,

Michael O'Keefe
Vice-President Technology.

Doug Patterson
2019–2020
Vice President Finance

As VP Finance, I want to present a general overview of our society's membership and where it stands relative to previous years. The SPWLA Society's finances are stable and its membership has shown a slight increase over last year, which is nice to see. It is the membership, especially active members, that make the SPWLA. The SPWLA's strength and financial health is connected to the size of our membership.

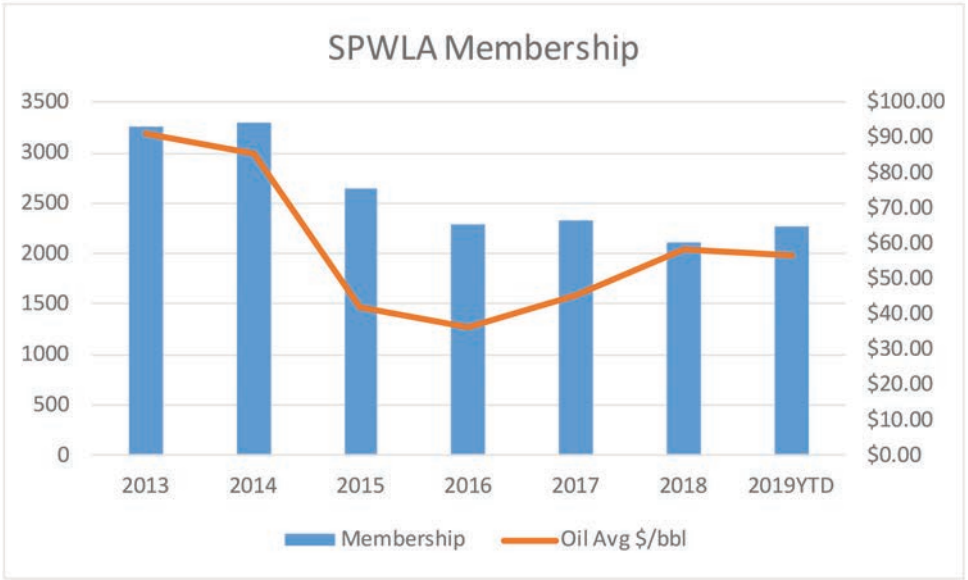
The chart below shows the professional membership numbers from 2013 to present day. Additionally, the chart shows the average annual West Texas crude oil price, in US$.

As we are all aware there is a strong correlation between the health of the Oil & Gas Industry and prices of the commodities that it produces. Of course, the industry's health ties directly with our membership numbers. The chart shows that in 2013 and 2014, with oil averaging in the $90/bbl to $85/bbl range, our membership was 3,253 and 3,290, respectively. In 2015, with the steep drop in oil prices of over 50%, to roughly $42/bbl, the membership did drop to 2,647. Since 2016, our membership has stabilized in the range between 2,327 to 2,119. It is good to see that, while the commodity price has been relatively flat over the last two years, our membership has shown some growth in 2019.

Of course, the greater our active membership, the stronger our society becomes with the ability to provide additional features to its members. As members, we comprise the society and we should use our own personal and professional networks to promote the SPWLA with its features, benefits and services. It is through the active engagement of members that will enable the SPWLA to prosper for many years to come, no matter what the commodity price is.

I encourage members with questions, ideas and suggestions related to membership and finance to contact me at VP-Finance@spwla.org.

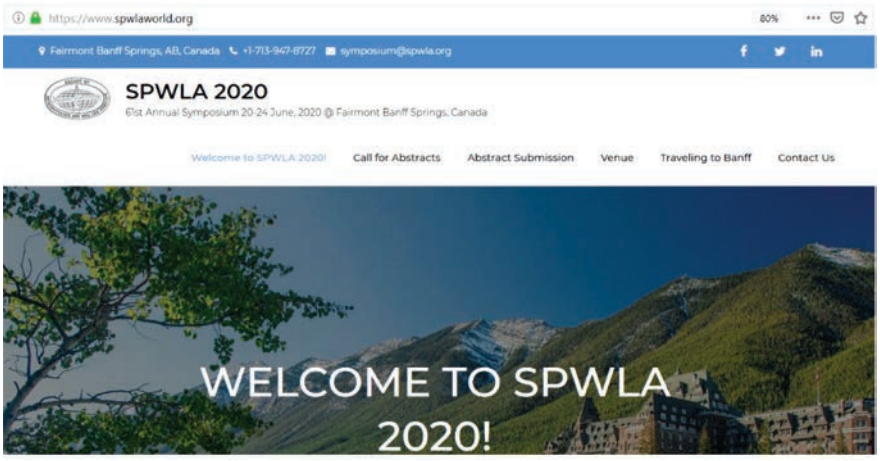
Best Regards,
Doug Patterson
Vice President Finance



Lin Liang
2019–2021 Vice President
Information Technology

Hello SPWLA community members,

The most exciting thing I would like to update you on is that the homepage for the 61st SPWLA Annual Logging Symposium that will be held at Banff next year is up and active. You are encouraged to browse the website (www.spwlaworld.org), register, and submit your abstracts for attending the event in such a beautiful place.



The second update is that we have formed a committee to plan and work together to enhance all IT related matters, such as the abstract submission and reviewing system, the official website modernization, moving some of the functionalities to public Cloud for cost reduction, further improvement of the symposium mobile app, etc. Currently, we have Tegwyn Perkins, and Adam Haecker on the IT committee, with continuous support from Sharon Johnson, Stephanie Turner, and Mehrnoosh Saneifar. Anybody familiar with webpage editing and website maintenance, Cloud techniques, please also consider volunteering for the IT Committee and email me vp-infotech@spwla.org if interested.

IT Committee members:

Tegwyn Perkins

Adam Haecker

Finally, it was my great honor to be invited, as the representative of SPWLA, to speak at the 11th UPC International Symposium on New Well Logging Techniques, held by the China University of Petroleum at Qingdao (see Chapter News Section). Together with Dr. Xie, we also gave two SPWLA Distinguished Speaker talks to the SPWLA East China Chapter. It was a great experience and thanks for the warm accommodation.

Photos from the 11th UPC International Symposium on New Well Logging Techniques

Lin Liang
Vice President Information Technology

Katerina Yared
2019-2020
Vice President Education

Dear Petrophysics friends,

I am very pleased to see the excitement we have at our monthly webinars; great attendance and great questions. Plus, our Formation Testing group is also having a very successful webinar series. Webinars are for sure a great means to fulfill our promise of knowledge sharing.

Along those lines I want to remind everyone that if you have a profound passion for a certain petrophysical topic you want to share for generations to come you can submit a request to be added to the "Nuggets of Wisdom" series. Or, if you have a product or service you want to share with the world we have "The More You Know" series that enables you to showcase that product or service with the world. Please contact me at vp-education@spwla.org for more information. I look forward to hearing from you!

As VP of Education I am also privileged to head our social media efforts with posts, likes and shares on anything and everything petrophysics. Please tag our SPWLA social media pages on LinkedIn, Facebook and Twitter to make sure your posts get the right attention.

Just recently, we had two people join our social media committee. I want to give a shout out to Mathilde Luycx and Rushil Pandya for volunteering their time to our social media committee. Thank you!

Last but not least our Education SIG has been hard at work as well and sent out a survey to the membership to help us to better understand how we can cater to the education needs of our members. Please make sure to complete the survey and provide us valuable feedback. Thank you!

I would like to thank the Education SIG committee members for volunteering their time and efforts for the greater good of our petrophysical community: Ahmed Badruzzaman, Abbie Morgan, Lesley Evans, Hani Elshahawi and Dan Krygowski.

The success of our society is dependent on volunteers like those mentioned above and the many others helping out here and there and everywhere. We wouldn't be as successful without them! Thank you!

I would like to remind you also that we are always looking for global distinguished speakers to visit our chapters and we would love to get nominations from chapters and regional directors about speakers they really like and want to hear again. Email me at vp-education@spwla.org for more information on the GDS.

Hope to see everyone at our monthly webinars!"

Katerina Yared
Vice President Education
(720) 431-7482

Regional Understandings – North America 1

Adam Haecker
NA 1 Director

Dear SPWLA Members,

As I write this column, the new season of chapter meetings has started here in the USA. My goal is to try and attend most of the chapters that are in my area this year. I have already been to Tulsa, Oklahoma City, OU and will be giving a presentation at TTU and Pittsburgh. Pittsburgh is in Kelly's area but I venture it counts as a visit. Hopefully, people submitted papers to the Banff symposium. The due date has likely passed by the time this has been printed. I submitted a paper in as a secondary author and am looking forward to another great year.

Please consider voting in the elections if you usually don't. We are sure to have another competitive board election in the spring and our voting rate is abysmal. I think we usually average around 600 votes in any SPWLA election and the society has over 2,100 members.

Things that I am working on for NA1 area are as follows

- Restarting the Texas A&M Student Chapter.
- Supporting the Tulsa Chapter in their first year having meetings since 2015.
- Sharing SPWLA media posts, Katerina does a great job.
- SPWLA Staff Bonus System
- Working with Jim Hemingway on candidate locations for the 2021 symposium.
- Helping members in transition to connect.

We had some serious discussion about some of the recent bylaw changes at the last board meeting. Specifically, it was felt by some members that some of the changes unfairly limit participation by a certain large service company. After a few hours of discussion, the board decided to try the current system for at least the next year. The next board can revise it if they feel that it is not fair to everyone. If you feel strongly one way or another feel free to contact me and I will relay your opinions as best I can.

Hope everyone is having a productive year and cheers.

Excelsior,
Adam Haecker

Regional Understandings – North America 2

Kelly Skuce
North America 2 Director

Dear SPWLA members,

Well the weather up here has finally turned from the warm days of summer to the crisp mornings and short, sunny days of fall. Actually, up here in Calgary and most of the Prairies there is a brief moment (let's call it a week) where fall looks to stay and be an actual season, then it quickly turns to winter around Halloween. Snow or no snow, it still gets pretty cool in the mornings (currently 2°C out there at noon). Enough about weather in Calgary, on to SPWLA regional director stuff.

Chapters have started up their monthly luncheons again after the summer. So here is the news from them….

- Denver Well Logging Society (DWLS) partnered with the RMAG, will have had their Fall Symposium on Multiscale Imaging for Reservoir Optimization by the time this column goes to print.
- Boston Chapter, partnered with the SPE, has a great event scheduled Nov 1–2 on "Porous Media: Structure, Flow and Dynamics Workshop." See the website for details. https://www.spwla.org/SPWLA/Chapters_SIGs/Chapters/North_America/Boston/Events.aspx
- Appalachia Chapter in Pittsburgh will be hosting my codirector for North America, Adam Haecker, in November. Check out his column for news on this event.
- New Orleans chapter will have had two great luncheons this fall with a third and final for the year planned for November 21. The talk will be given by Bo Gong, a research petrophysicist with Chevron ETC. Bo will present "Using a Neural Network to Estimate Net Sand from Borehole Images in Laminated Deepwater Reservoirs."
- San Joaquin Well Logging Society (SJWLS) in Bakersfield hosted a luncheon presentation from Todd Guidry, Technical Advisor of Core Labs, on "Introduction to Reservoir Fluid Behavior, Production Trends and Analysis." The SJWLS would also like to acknowledge some of their new board members for stepping up for lost board members. Eva Lopez, Secretary, and Dr. Dayanand Saini, Publicity. Dr. Saini is also looking to create a student chapter at the California State University Bakersfield. Way to go SJWLS!
- And speaking of Student Chapters, the Texas A&M Kingsville (TAMUK) students just received their University authority to form their own SPWLA student chapter!

Todd Guidry accepting his award from the SJWLS.

Regional Understandings – North America 2

All of these events look very informative! If you have some reports or pictures from any of these events and you would like to see them here, send them to me at Director-NA2@spwla.org.

Not a lot of SPWLA stuff up here besides helping with the planning of next year's symposium in Banff (looks to be a great one), attend local monthly Canadian Well Logging Society meetings, emails to my chapter responsibilities, and calling in to the bimonthly Board of Directors meetings. I am contemplating a visit down south, as Bakersfield always invites me down for one of their meetings. We will have to see how cold it does get up here!

On a last note, there was a lot of discussion at the last Board of Directors meeting about the new changes voted on recently to the SPWLA. I am torn on some changes, but relieved on others. If you have comments please forward them to me and I can help voice your concerns to the current Board and help make changes if needed (I am here for next year's Board too!). It's also election time up here in Canada and by the time this column comes out there may be some change to the federal government. Hopefully to the positive on oil and gas exploration here in Canada. So remember, if you don't like what is happening, get out and vote! This is good for both government and the SPWLA.

'Nuff said!

Kelly Skuce

Regional Understandings – Middle East and Africa

Shouxaing "Mark" Ma
2019–2020 MEA
Regional Director

Dear Colleagues,

Summer is over and the beautiful winter weather is returning to the Middle East; mild sunshine and blue sky during the day, and bright starts in the night! This is the time not only for enjoyable leisure, but also productive business and that is what the SPWLA Saudi Arabia Chapter (SAC) is currently actively pursuing.

The 7th SPWLA SAC Topical Workshop will be held at Dhahran Techno Velley on 5 November 2019. The topic to be discussed will be "Advancement in Geochemistry and Its Applications in E&P," covering the geochemistry of rock, oil, and water" You are welcome to join us, especially for those who are located in the region.

Then, 13–15 January 2020, the International Petroleum Technology Conference, a much larger international technical event, will be held here in the Dhahran area, and the organizing teams have been working hard to ensure a successful event.

And again, you are all welcome to actively participate in this conference, and also visit the region, the Capital of Oil!

Always looking forward to seeing you in Dhahran, Saudi Arabia.

S. Mark Ma
SPWLA Director – Middle East and Africa Region

SPWLA THIRD BOARD OF DIRECTORS MEETING
SPWLA BUSINESS OFFICE
HOUSTON, TEXAS
OCTOBER 9, 2019

President, Jesús M. Salazar called the meeting to order at 8:01 a.m. In attendance Vice President Finance Doug Patterson, Executive Director, Sharon Johnson. Remote attendance President-Elect, James "Jim" Hemingway, Vice President Technology, Michael O'Keefe, Vice President Education, Katerina Yared, Vice President Publications, Tom Neville, Vice President Information Technology, Lin Liang, Regional Director N. America 1, Adam Haecker, Regional Director N. America 2, Kelly Skuce, Regional Director Latin America, Nadege Bize Forest, Regional Director Europe, Craig Lindsay, Regional Director Asia/Australia, Jennifer Market, Regional Director Middle East, Mark Ma

A motion made by Doug Patterson to waive the reading of the minutes from the August 8th board meeting was seconded by Katerina Yared. All approved, and the motion passed.

Action Item: Doug Patterson will update his proposed SPWLA employee bonus plan and send it to the Board for review and vote.

Action Item: Katerina Yared to finalize a committee for the Petrophysics Professional Certification for SPWLA.

Action Item: Jennifer Market to reach out to Former Presidents of the International SPWLA and Perth Chapter (FESAus) for historical background of the chapter in the effort to resolve internal arguments within the current board.

A motion made by Jim Hemingway to approve the newly formed Hydrocarbon Reserves SIG was tabled until Board member questions concerning member dues fees is clarified.

Action Item: Tom Neville to send a reminder to the Board members for Newsletter content on the 20th of the preceding month of publication.

A motion made by Michael O'Keefe for an additional $1,500 to the VP Technology budget for customization enhancements to the abstract submission platform for reviewers and ranking process was seconded by Jim Hemingway. All approved, and the motion passed.

Action Item: Call to all Board members – suggestions for the numbering system (paper identifiers) for the Heritage Program.

Action Item: Jim Hemingway to solicit additional Chapters for a bid to host the SPWLA Annual Symposium in 2021.

Action Item: Sharon Johnson to research the SAID bylaws to reinstate the Chapter.

Action Item: Jesús Salazar follow up on a contact from Venezuela and share with Nadege Bize Forest.

Action Item: Craig Lindsay to follow up with the newly formed chapter, "Central European Formation Evaluation Society (CEFES)," in Bucharest, Romania, to offer assistance through the bylaws and charter process.

A motion made by Doug Patterson to be added to the SPWLA bank account signature cards was seconded by Adam Haecker. All approved, and the motion passed.

Action Item: Michael O'Keefe to open discussion on the SPWLA policy for the BOD nominating committee member selection by the Past President.

A motion made by Doug Patterson to adjourn the meeting at 1:17 p.m. was seconded by Michael O'Keefe. All approved, and the motion passed.

Respectively Submitted by
Sharon Johnson
Executive Director

Next BOD meeting: December 4, 2019, SPWLA Business Office Houston and Remotely

Tales from the Oil Patch: 1970s in the Louisiana Gulf Coast—Vuggy Sandstones? (Surely You Jest, Dr. T.)

E. C. Thomas

Formation evaluation requires understanding the relationship between various rock types, their responses when probed by electric, nuclear and acoustic energy and the fluids in the pore system of each rock type. For each rock type there are truisms that help us to assign various constants in the equations that transform tool response and needed rock property. This methodology works only when our assumed truisms are really true and are confirmed by "looking at the rocks" as Archie suggested.

The Gulf Coast is predominantly a sandstone province and carbonate rock types and their properties are put into many folks' last file drawer. One of the resulting truisms for sandstones then becomes no vugs. We recognize the problem that arises when one uses the Wyllie equation in vuggy carbonates; we must adjust constants in the equation to determine the correct porosity. But since sandstones have no vugs, adjustment for this effect is seldom if ever used.

But how are vugs formed in sandstones? Let's agree that a vug is a pore larger than the median grain size of a given rock sample. The mechanism to create vugs in any rock type is through diagenesis by dissolution of the more soluble grains. In the case of sandstones, the more soluble grains are feldspars. This occurrence of vugs can be clearly seen in thin section. A second confirmation occurred with the advent of density logging producing values of porosity that agreed with core analysis and those values calculated from acoustic travel times did not. In every comparison I made, the Willey equation did not see some pore volume. From then, on density logs replaced acoustic logs for porosity determination in sandstone reservoirs in the Gulf Coast. As wells are drilled deeper into older formation these rocks have had more time to undergo digenesis via grain solution and the likelihood of seeing vugs in sandstones. And one needs to remember that as porosity falls, it is more likely that a larger percentage of the pores are likely be due to vugs. Vuggy porosity has a very different porosity-permeability relationship than sandstone without vugs. Thus, you deep-drillers need to revisit your inflow prediction to make sure you are using a valid porosity-permeability transform for diagenetically altered rocks.

But the facts above are only the prelude to the 'tale' yet to come. In the 1970s we were systematically making determinations of ROS in assets across the entire Gulf Coast. One such asset was a shallow reservoir associated with a shallow salt dome. Openhole logs pegged the porosity at 35%. Sidewall samples determined the rock type as a well-sorted medium-grain-sized unconsolidated sand. Many different methods were used to make these determinations. To improve our knowledge of the petrophysical properties of this reservoir rock type, we obtained whole core for geologic and petrophysical measurements. I was in the core lab when we opened the core barrel and exposed the end of the core. None of the staff present was prepared for what we observed. The first look was hard to describe; the best I can do is compare the end of the core to the surface of a freshly opened pomegranate. On a closer examination, bubbles of crude squeezed against the sand grains like small soap bubbles except that the bubbles were much larger than the sand grains and the bubbles were all approximately the same size. The gas in the bubbles had actually made vug-like vesicles very similar to the bubbles in lava. Obviously, the core was so disturbed it was of no value to measure petrophysical properties and until I could determine what happened and how to fix it, only then would I be able to sell another core. A bit of detective work led to the discovery that the field crude had 10% CO_2 and the mud engineer had not treated the drilling mud to scrub out the CO_2. Thus, the bubbles were CO_2 from the crude that acted like a soda pop resulting in a man-made vuggy sand. As the bubbles formed they expanded the unconsolidated core until the fluffed-up core filled the void space in the inner core barrel. One more lesson learned!

You'll Never Lose a Resistivity Interpretation Argument When James Clerk Maxwell is on Your Side

Barbara Anderson
SPWLA President
1994–1995
SPWLA Gold Medal for
Technical Achievement
2007

All of the theory needed for modeling the response of resistivity logging tools is derived from Maxwell's equations, which are shown in Fig. 1. The problem seems simple—everything we need to know is shown in this 3- × 3-in. space. We can all go home now. However, the elegance of the solution is due to Maxwell's genius in capturing the hidden complexity of the problem. There are still details left for us to explore.

(A) The law of total currents	$\mathbf{J}_{\text{tot}} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$
(B) The equation of magnetic force	$\mu \mathbf{H} = \nabla \times \mathbf{A}$
(C) Ampère's circuital law	$\nabla \times \mathbf{H} = \mathbf{J}_{\text{tot}}$
(D) Electromotive force created by convection, induction, and by static electricity. (This is in effect the Lorentz force)	$\mathbf{E} = \mu \mathbf{v} \times \mathbf{H} - \frac{\partial \mathbf{A}}{\partial t} - \nabla \phi$
(E) The electric elasticity equation	$\mathbf{E} = \frac{1}{\varepsilon}\mathbf{D}$
(F) Ohm's law	$\mathbf{E} = \frac{1}{\sigma}\mathbf{J}$
(G) Gauss's law	$\nabla \cdot \mathbf{D} = \rho$
(H) Equation of continuity	$\nabla \cdot \mathbf{J} = -\frac{\partial \rho}{\partial t}$

Fig. 1—Maxwell's equations as published in 1873, shown in modern vector notation (typesetting courtesy of Wikipedia).

I 've been working with Maxwell's equations since 1966, and I still am surprised by the amount of information that they can reveal. In 2006, I was further impressed by Maxwell's contributions to other areas of physics during a trip to Aberdeen to give an invited talk at their chapter meeting. The talk was scheduled during the same week that the University of Aberdeen was hosting a conference on "The Impact of Maxwell's Science" to celebrate the 150-year anniversary since Maxwell began teaching there as a professor of natural science.

The focus of the conference was on the diversity of Maxwell's contributions to physics. In order to represent the petrophysics community, Jim White of the Aberdeen Chapter arranged for me to give a talk on the topic of "How Maxwell's Equations are Used on a Daily Basis in Downhole Logging for Oil and Gas Exploration." Figure 2 is a group photo of the conference attendees posed under a commemorative bust of Maxwell (the author of this column is standing directly under the bust of Maxwell).

Several talks described how Maxwell's most notable achievement of formulating the relationship between electricity, magnetism and light had led to the future development of radio communication and radar. Other work laid the foundations of color science and color photography by a method that is used today in TVs, computer displays and cell phones. His contemporaries described him as the leading molecular scientist of the 19th century. He also made significant contributions in astronomy, optics, mechanics and control theory, and founded the modern field of electrical engineering.

At the end of the day, I felt quite inadequate. Others in the past have also recognized the importance of Maxwell's work, although it is rarely publicized. It is reported that when Albert Einstein was told during a visit to Cambridge University that he had done great things only because he stood on Newton's shoulders, Einstein replied that it was Maxwell's shoulders he stood on, and not Newton's.

The conference talks made me curious about how Maxwell became so creative in comparison to his contemporaries, and I began to search for a biography that might describe his thought processes. The most insightful one available is "The Man Who Changed Everything—The Life and Times of James Clerk Maxwell" by a British author, Basil Mahon. Mahon explains how Maxwell developed "thought experiments" to solve complex problems. As a child he was curious, always asking "what's the go of it," and his family provided explanations. Later in school, he attacked problems by first reading everything he could about

Fig. 2—Attendees at the 2006 conference "The Impact of Maxwell's Science," held at the University of Aberdeen, and posed under a commemorative bust of Maxwell.

them and then writing down only what he believed was helpful (called amplification and reduction). The next step was to make physical observations, such as constructing a color top to understand the difference between mixing light and mixing pigments, or observing turbulent flow in rocky streams to visualize electrical eddy currents. The final theory was developed when the observations could be thoroughly explained. The book is both technically interesting and light reading (no equations).

Getting back to the promised help from Maxwell, all resistivity modeling codes are a programmed solution to Maxwell's equations with boundary conditions that describe a particular geometry. Because resistivity tools survey large volumes of formation, interpretation can become complicated. Some major causes of complication are (1) not having enough measurements to guarantee a unique solution, (2) the sensitivity of measurements decreasing drastically with distance, and (3) 1D or 2D solutions being assumed when solutions are really 3D (or 4D).

Computer modeling makes its greatest contribution in complicated situations that are beyond the scope of interpretation software. By modeling trial sets of interpreted resistivity values and bed dimensions, one can discard solutions where a computed log and field log disagree and concentrate on refining the most reasonable solution until both logs are in agreement. The solution is guaranteed to be *mathematically* correct by Maxwell's equations, although it should also be validated to make sure that it makes *petrophysical* sense by similar modeling of nonresistivity logs.

The following are two examples where modeling was used to resolve interpretation arguments. The first is a strange log where there was a disagreement about whether it was caused by a broken tool or was an actual feature of the formation. The field log is shown on the left in Fig. 3. Note the cyclic behavior of both Dual Induction logs. The client argued that the oscillations were so regular that they couldn't be caused by geological features, but must be a tool problem.

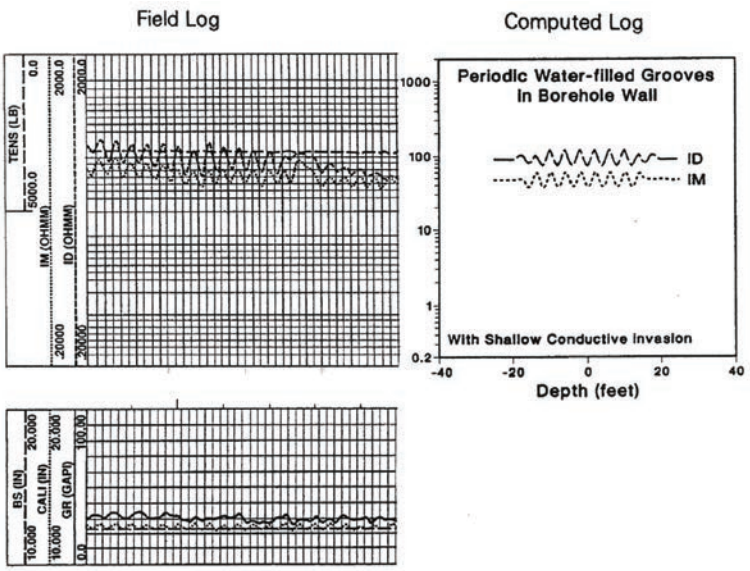


Fig. 3—Field log (left) and computed log (right) showing cyclic behavior of a Dual Induction log caused by water-filled grooves in the borehole wall.

However, the caliper indicates that the borehole contains periodic grooves. Also, an auxiliary measurement sub indicated that the oil-based mud had broken down and water was in the continuous phase, making the mud in the region conductive. Using a 2D finite-element code, it was found that mud resistivities around 0.5 Ω-m produced oscillations that closely resembled those on the field log. After adding shallow conductive invasion to the model, the final computed log, shown on the right in Fig. 3, is in good agreement with the field log.

An added Fourier analysis showed that conductive features must be within 15 in. of the borehole axis to cause significant perturbations on the Dual Induction logs. A more detailed discussion of this example is given in Anderson and Barber (1988).

A second example illustrates how an unexpected horn on 2-MHz LWD logs turned out to be a useful indicator of bed-boundary crossings in highly deviated wells. In this case, the computed log in Fig. 4 (right) was modeled first, before the well was drilled, so it could be used to confirm that we could identify exactly when the tool crossed the interface between a 1 Ω-m shale and an 800 Ω-m gas sand in a 70° deviated well. The subsequent field log (left) is in good agreement, showing exactly when the boundary was crossed.

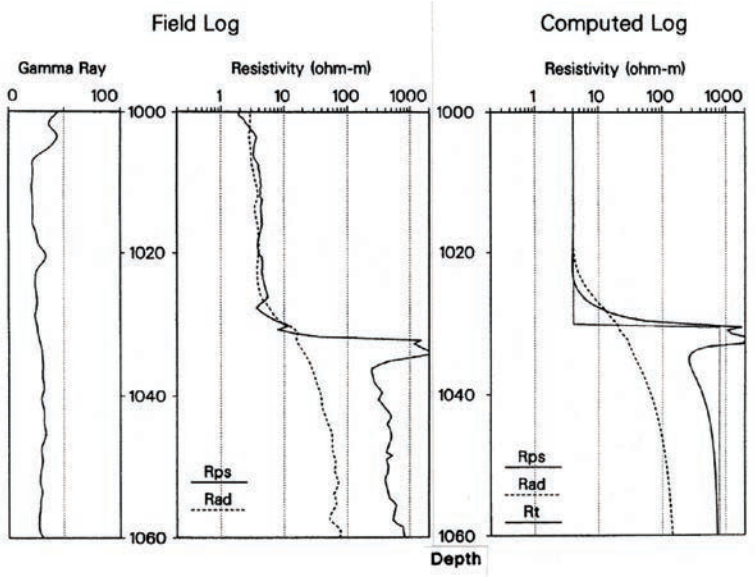


Fig. 4—Field log (left) and computed log (right) showing that the horn that appears on 2-MHz LWD logs at high-contrast bed boundaries in deviated wells is a real feature and not an isolated tool artifact.

The horn is caused by a discontinuity of the electric field that occurs when the tool crosses the boundary at a steep angle. It can be explained by a close examination of Maxwell's equations. Remarkably the information was hidden in the equations and first revealed to us by the modeled log and confirmed by the field log. Maxwell comes to our aid again! A more detailed discussion of this example is given in the Anderson et al. (1990).

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Society of Core Analysts 33rd International Symposium
Pau, France, August 26–30, 2019
Abstracts

Oral Presentations

SCA2019-001. Pore-Scale Imaging and Determination of Relative Permeability and Capillary Pressure in a Mixed-Wet Carbonate Reservoir Rock at Subsurface Conditions

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We use X-ray microtomography combined with a high-pressure high-temperature steady-state flow apparatus to simultaneously measure relative permeability and capillary pressure in a carbonate core from a producing oil field from the Middle East. The native reservoir wettability conditions were restored by aging the sample at 10 MPa and 80°C. Imaging and measurement of steady-state relative permeability were performed at eight water fractional flows (f_w = 0, 0.15, 0.3, 0.5, 0.7, 0.85, 0.95, 1), while measuring the pressure differential across the sample. The formation brine was doped with 30 wt% KI to resolve the fluid saturation in the macro- and the subresolution pores. The measured relative permeabilities indicated favorable oil recovery with a crossover saturation above 60%. Below this saturation the water relative permeability is low, while above it, oil still flows through thin layers resulting in additional recovery. We quantify oil recovery from both macropores and micropores. The measurements of the interfacial curvature indicated negative capillary pressure that decreased with an increase in fractional flow, which is a signature of predominantly oil-wet media. Overall, this work has important implications for improved oil recovery in mixed-wet reservoirs. The measured relative permeability, capillary pressure and fluid distribution can also be used to benchmark and validate pore-scale models.

SCA2019-002. Density Functional Hydrodynamics in Multiscale Pore Systems: Chemical Potential Drive

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We use the method of density functional hydrodynamics (DFH) to model compositional multiphase flows in natural cores at the pore-scale. In previous publications, the authors demonstrated that DFH covers many diverse pore-scale phenomena, starting from those inherent in RCA and SCAL measurements, and extending to much more complex EOR processes. We perform the pore-scale modelling of multiphase flow scenarios by means of the direct hydrodynamic (DHD) simulator, which is a numerical implementation of the DFH. In the present work, we consider the problem of numerical modelling of fluid transport in pore systems with voids and channels when the range of pore sizes exceed several orders of magnitude. Such situations are well known for carbonate reservoirs, where narrow pore channels of micrometer range can coexist and interconnect with vugs of millimeter or centimeter range. In such multiscale systems one cannot use the standard DFH approach for pore-scale modeling, primarily because the needed increase in scanning resolution that is required to resolve small pores adequately, leads to a field-of-view reduction that compromises the representation of large pores. In order to address this challenge, we suggest a novel approach, in which transport in small-size pores is described by an upscaled effective model, while the transport in large pores is still described by the DFH. The upscaled effective model is derived from the exact DFH equations using asymptotic expansion in respect to small-size characterization parameter. This effective model retains the properties of DFH-like chemical and multiphase transport, thus making it applicable to the same range of phenomena as DFH itself. The model is based on the concept that the transport is driven by gradients of chemical potentials of the components present in the mixture. This is a significant generalization of the Darcy transport model since the proposed new model incorporates diffusion transport in addition to the usual pressure-driven transport. In the present work we provide several multiphase transport numerical examples including (a) upscaling to chemical potential drive (CPD) model, and (b) combined modeling of large pores by DFH and small pores by CPD.

SCA2019-003. Uncertainty Span for Relative Permeability and Capillary Pressure by Varying Wettability and Spatiality Flow Directions Using Pore-Scale Modeling

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Relative permeability and capillary pressure are key properties within special core analysis and provide crucial information for full field simulation models. These properties are traditionally obtained by multiphase flow experiments, however pore-scale modeling has during the last decade shown to add significant information as well as being less time-consuming to obtain.

Pore-scale modeling has been performed by using the lattice Boltzmann method directly on the digital rock models obtained by high resolution micro-CT images on end-trims available when plugs are prepared for traditional SCAL experiments. These digital rock models map the pore structure and are used for direct simulations of two-phase flow to relative permeability curves.

Various types of wettability conditions are introduced by a wettability map that opens for local variations of wettability on the pore space at the pore level. Focus has been to distribute realistic wettabilities representative for the Norwegian Continental Shelf, which is experiencing weakly wetting conditions and no strong preference either to water or oil. Spanning a realistic wettability map and enabling flow in three directions, a large amount of relative permeability curves is obtained. The resulting relative permeabilities hence estimate the uncertainty of the obtained flow properties on a spatial but specific pore structure with varying, but realistic wettabilities.

The obtained relative permeability curves are compared with results obtained by traditional SCAL analysis on similar core material from the Norwegian Continental Shelf. The results are also compared

with the SCAL model provided for full-field simulations for the same field. The results from the pore-scale simulations are within the uncertainty span of the SCAL models, mimic the traditional SCAL experiments and shows that pore-scale modeling can provide a time- and cost-effective tool to provide SCAL models with uncertainties.

SCA2019-004. Permeability Alteration by Salt Precipitation: Numerical and Experimental Investigation Using X-Ray Radiography

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The injection of a gas phase through a water-saturated porous medium can reduce the water saturation not only by displacement mechanisms but also by evaporation mechanisms. In the presence of brine, this process can induce salt crystallization and precipitation within the porous medium with a risk of permeability alteration. In the field of gas production and storage, the occurrence of such a phenomenon can have detrimental consequence on the well productivity or injectivity.

In this work, we investigated experimentally and numerically the effect of dry-gas injection on salt precipitation and permeability impairment. State-of-the-art equipment designed for high throughput coreflood experimentation was used to capture the dynamic of salt migration using X-ray radiography. A set of experiments have been conducted on a sample of Bentheimer sandstone (10 mm in diameter and 20 mm in length) as well as a two-layer composite sample with a significant permeability contrast. Experiments were conducted using nitrogen and KBr brine with different boundary conditions (i.e., with and without capillary contact).

Results showed that salt precipitation results from the interplay of different parameters, namely pressure gradient, brine salinity, capillary forces and vapor partial pressure. Experimental observations indicate that in the case of dry-gas injection, salt systematically precipitates but permeability alteration is observed only if a capillary contact is maintained with the brine. We built a 2D flow model integrating two-phase Darcy flow, capillary forces, salt effect on vapor partial pressure, dissolved salt transport, as well as the different PVT equilibria needed to describe properly the systems. Once calibrated, the model showed good predictability of laboratory-scale experiment and thus can be used for parametrical study and upscaled to the wellbore scale.

SCA2019-005. Steady-State Two-Phase Flow in Porous Media: Laboratory Validation of Flow-Dependent Relative Permeability Scaling

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The phenomenology of steady-state two-phase flow in porous media is recorded in SCAL relative permeability diagrams. Conventionally, relative permeabilities are considered to be functions of saturation, yet this has been put into challenge by theoretical, numerical and laboratory studies that have revealed a significant dependency on the flow rates. These studies suggest that relative permeability models should include the functional dependence on flow intensities. Just recently a general form of dependence has been inferred, based on extensive simulations with the DeProF model for steady-state two-phase flow in pore networks. The simulations revealed a systematic dependence of the relative permeabilities on the local flow-rate intensities that can be described analytically by a universal scaling functional form of the actual independent variables of the process, namely, the capillary number, *Ca*, and the flow-rate ratio, *r*.

In this work, we present the preliminary results of a systematic laboratory study using a high throughput coreflood experimentation setup, whereby SCAL measurements have been taken on a sandstone core across different flow conditions spanning six orders of magnitude on *Ca* and *r*. The scope is to provide a preliminary proof of concept, to assess the applicability of the model and validate its specificity. The proposed scaling opens new possibilities in improving SCAL protocols and other important applications, e.g., field-scale simulators.

SCA2019-006. Improved Method for Complete Gas-Brine Imbibition Relative Permeability Curves

M. Ben Clennell[1,*], Cameron White[1], Ausama Giwelli[1], Matt Myers[1], Lionel Esteban[1], Michael Cullingford[2], William Richardson[3], Gavin Ward[2], Matt Waugh[2], Scott Cole[2], Ashley Hunt[2], and Peter Bright[2§]
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Standard test methods for measuring imbibition gas-brine relative permeability on reservoir core samples often lead to nonuniform brine saturation. During cocurrent flow, the brine tends to bank up at the sample inlet and redistributes slowly, even with fractional flow of gas to brine of 400:1 or more. The first reliable Rel Perm point is often only attained after a brine saturation of around S_w = 40% is achieved, leaving a data gap between S_{wirr} and this point. The consequent poor definition of the shape of the Rel Perm function can lead to uncertainty in the performance of gas reservoirs undergoing depletion drive with an encroaching aquifer or subjected to a waterflood.

We have developed new procedures to precondition brine saturation outside of the test rig and progress it in small increments to fill in the data gap at low S_w, before continuing with a cocurrent flood to the gas permeability endpoint. The method was applied to series of sandstone samples from gas reservoirs from the NW Shelf of Australia, and a Berea standard. We found that the complete imbibition relative permeability curve is typically 'S' shaped or has a rolling over, convex-up shape that is markedly different from the concave-up, Corey Rel Perm curve usually fitted to SCAL test data. This finding may have an economic upside if the reservoir produces gas at a high rate for longer than was originally predicted based on the old Rel Perm curves.

SCA2019-007. Workflow for Upscaling Wettability From the Nano- to Core-Scales

Maja Rücker[1,3], Willem-Bart Bartels[2,3], Tom Bultreys[1,4,6], Marijn Boone[7], Kamaljit Singh[5,6], Gaetano Garfi[6], Alessio Scanziani [6], Catherine Spurin[6], Sherifat Yesufu[1], Samuel. Krevor[6], Martin. J. Blunt[6], Ove Wilson[3], Hassan Mahani[3], Veerle Cnudde[2,4], Paul F. Luckham[1], Apostolos Georgiadis[1,3], and Steffen Berg[1,3,6]
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Wettability is a key factor influencing multiphase flow in porous media. In addition to the average contact angle, the spatial distribution of contact angles along the porous medium is important, as it directly controls the connectivity of wetting and nonwetting phases. The controlling factors may not only relate to the surface chemistry of minerals but also to their texture, which implies that a length-scale range from nanometers to centimeters has to be considered. So far, an integrated workflow addressing wettability consistently through the different scales does not exist.

In this study, we demonstrate that such a workflow is possible by combining microcomputed tomography imaging with atomic force microscopy (AFM). We find that in a carbonate rock, consisting of 99.9% calcite with a dual-porosity structure, wettability is ultimately controlled by the surface texture of the mineral. Roughness and texture variation within the rock control the capillary pressure required for initializing proper crude-oil-rock contacts that allow aging and subsequent wettability alteration. AFM enables us to characterize such surface-fluid interactions and to investigate the surface texture. In this study, we use AFM to image nanoscale fluid-configurations in situ in 3D at connate water saturation and compare the fluid configuration with simulations on the rock surface assuming different capillary pressures.

SCA2019-008. Is Contact Angle a Cause or an Effect?—A Cautionary Tale

Douglas Ruth[1]
[1]University of Manitoba, Winnipeg, Manitoba, Canada

The most influential parameter on the behavior of two-component flow in porous media is “wettability”. When wettability is being characterized, the most frequently used parameter is the “contact angle”. When a fluid-drop is placed on a solid surface, in the presence of a second, surrounding fluid, the fluid-fluid surface contacts the solid-surface at an angle that is typically measured through the fluid-drop. If this angle is less than 90°, the fluid in the drop is said to “wet” the surface. If this angle is greater than 90°, the surrounding fluid is said to “wet” the surface. This definition is universally accepted and appears to be scientifically justifiable, at least for a static situation where the solid surface is horizontal.

Recently, this concept has been extended to characterize wettability in nonstatic situations using high-resolution, two-dimensional digital images of multicomponent systems. Using simple thought experiments and published experimental results, many of them decades old, it is demonstrated that contact angles are not primary parameters—their values depend on many other parameters. Using these arguments, it is demonstrated that contact angles are not the cause of wettability behavior but the effect of wettability behavior and other parameters. The result of this is that the contact angle cannot be used as a primary indicator of wettability except in very restricted situations. Furthermore, it is demonstrated that even for the simple case of a capillary interface in a vertical tube, attempting to use simply a two-dimensional image to determine the contact angle can result in a wide range of measured values. This observation is consistent with some published experimental results. It follows that contact angles measured in two-dimensions cannot be trusted to provide accurate values and these values should not be used to characterize the wettability of the system.

SCA2019-009. The Link Between Microscale Contact-Angle Measurements and Core-scale Wettability

Chenhao Sun[1], James McClure[2], Mehdi, Shabaninejad[3], Peyman Mostaghimi[1], Steffen Berg[4] , and Ryan T. Armstrong[1],*
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Wettability is an important parameter for assessing the performance and optimum recovery scenario for hydrocarbon reservoirs. Relative permeability- and capillary pressure-saturation functions show a high sensitivity to wettability. At the core scale, wettability is defined via the capillary pressure drainage and imbibition cycle, e.g., as Amott-Harvey or USBM indices. At the microscale, the concept of contact angle is used, which until recently was not experimentally possible to determine in a porous rock at reservoir conditions.

In this work, the Gauss-Bonnet theorem is used to provide a link between $P_c(S_w)$ and measured distributions of microscale contact angles. We propose that the wettability of a porous system can be described by geometrical constraints that define the state of immiscible fluids. The constraint describes the range of possible contact angles and interfacial curvatures that can exist for a given system. We present measurements on a sandstone rock for which the USBM index, $P_c(S_w)$, and pore-scale contact angles are measured. The results show that pore-scale contact-angle measurements can be predicted from capillary pressure data within 4 to 8% error. This provides a general framework on how petrophysical data can be used to describe the geometrical state of fluids in a porous media.

SCA2019-010. Effect of Fractures on Hot-Solvent Injection in Viscous Oil: A Study Using HP-HT Micromodel

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In this study, a transparent glass micromodel is used to study the physicochemical behavior of a solvent / viscous oil system with

pressures and temperatures in the range 8 to 100 bar and 60 to 110°C respectively, allowing the visual observation of the phenomena at the actual pressure and temperature reservoir conditions of interest. The experiments, covering immiscible, miscible and supercritical conditions, reveal the influence of pressure, temperature, connate water and fractures, on the oil recovery and flow behavior. A physicochemical interpretation is performed, by both analytical and numerical methods, resulting in deep understanding of the miscible process at microscopic scale. It is found that the most interesting behavior in terms of oil recovery (for the type of solvent used in this work) is given by the ratio of fracture permeability to intact matrix permeability, which is commonly referred to as excess permeability index. Being the micromodel vertically oriented with the lighter solvent injected from the top, the stability of the experiments is also classified: although solvent fingers are expected as buoyancy is not strong enough to prevent their initiation and growth, in reality they are only seen in a minority of experiments. This behavior is explained due to the contributions of the transverse dispersion, which smooths out the fingers as they grow, and to the fractures on the stabilization of the flow inside the matrix.

SCA2019-011. Screening of EOR Potential on the Pore Scale by Statistical and Topological Means

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Chemical EOR processes modify properties of fluid-fluid and rock-fluid interfaces in the pore space with the aim of mobilizing additional oil. The initial mobilization takes place on the scale of the individual pore. Therefore, observations on the pore scale provide valuable insights into water-oil displacement mechanisms; the understanding of these mechanisms enables an efficient design of the injection water chemistry.

In this article, we present a first step towards a statistical and topological fingerprint of EOR processes used to characterize and optimize EOR processes. We use microfluidics to observe changes in the oil distribution in the pore space and the formation of emulsion phases. The oleic phase was analyzed by statistical and topological means showing a systematic change as a function of alkali concentration. In particular, Lorenz diagrams and the normalized Euler characteristic appeared as sensitive to changes in the water chemistry. It turned out that the displacement processes are influenced by emulsion formation, especially at low and high alkali concentrations. This is implicitly reflected in the statistical and topological analysis, but has not yet been explicitly accounted for.

SCA2019-012. An Experimental Investigation of Surface-Modified Silica Nanoparticles in the Injection Water for Enhanced Oil Recovery

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Extraction of oil trapped after conventional waterflooding still poses huge challenges in the oil industry. Therefore, innovative enhanced oil recovery (EOR) technologies are required to run the production more economically. Recent advances suggest renewed application of surface-modified nanoparticles (NPs) for oil recovery. The advantages of these NPs include improved properties (e.g., stability, stabilization of emulsions, etc.), which make them appropriate to improve microscopic sweep efficiency of a waterflood. However, the EOR mechanisms of NPs are not well understood.

This work evaluates the effect of four types of polymer-coated silica NPs as additives to the injection water for EOR. The NPs were examined as tertiary recovery agents using water-wet Berea sandstone rocks at 60°C. Crude oil was obtained from a North Sea field. The NPs were diluted to 0.1 wt% in seawater before injection. The transport behavior of the NPs and their interactions with the rock system were also investigated to reveal possible EOR mechanisms. The flooding experiments showed that the NPs could effectively increment oil recovery in waterflooded reservoirs. The incremental oil recovery was up to 14% of original oil in place (OOIP). Displacement studies revealed that oil production was affected by interfacial tension reduction and wettability effect; however, the migration behavior of the NPs through the rock suggested that log-jamming effect and formation of NP-stabilized emulsions were relevant explanations for the mobilization of residual oil.

SCA2019-013. Permeability Prediction Using Multivariant Structural Regression

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A novel method for permeability prediction is presented using multivariant structural regression. A machine-learning-based model is trained using a large number of synthetic datasets (2,190, extrapolated to 219,000) constructed using a variety of object-based techniques. Permeability, calculated on each of these networks using traditional digital rock approaches, was used as a target function for a multivariant description of the pore-network structure, created from the statistics of a discrete description of grains, pores and throats, generated through image analysis. A regression model was created using an extra-trees method with an error of <4% on the target set. This model was then validated using a composite series of data created both from proprietary datasets of carbonate and sandstone samples and open-source data available from the Digital Rocks Portal (www.digitalrocksporta.org) with a root mean square fractional error of <25%. Such an approach has wide applicability to problems of heterogeneity and scale in pore-scale analysis of porous media, particularly as it has the potential of being applicable on 2D as well as 3D data.

SCA2019-014. A Fast FFT Method for 3D Pore-Scale Rock Typing of Heterogeneous Rock Samples via Minkowski Functionals and Hydraulic Attributes

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The integration of numerical simulation and physical

measurements, e.g., digital and conventional core analysis, requires the consideration of significant sample sizes when heterogeneous core samples are considered. In such cases, a hierarchical upscaling of properties may be achieved through a workflow of partitioning the sample into homogeneous regions followed by characterization of these homogeneous regions and upscaling of properties. Examples of such heterogeneities include fine laminations in core samples or different microporosity types as a consequence of source-rock components and diagenesis.

In this work, we use regional measures based on the Minkowski functionals as well as local saturation information derived through a morphological capillary drainage transform as a basis for such a classification/partitioning. An important consideration is the size of the measurement elements used, which could be considerable in the case of larger heterogeneities; in such case the calculation of the regional measures can be computationally very expensive. Here, we introduce an FFT approach to calculate these measures locally, using their additivity. The algorithms are compared against direct summation techniques and shift-overlap approaches for a selection of different averaging supports to illustrate their speed and practical applicability. We consider a range of artificial Boolean models to illustrate the effect of including hydraulic information on the resulting classifications scheme. This allows the determination of bias, since for these model systems local classes are known ab-initio. The classification framework is tested by comparing to the known initial microstructure distribution and relative bias quantified in terms of choice of averaging elements (size and shape). Importantly, depending on the actual morphological transition between microtype partitions, partitions including hydraulic attributes differ from pure morphological partitions with applications to electrofacies and hydraulic unit definitions.

SCA2019-015. Estimation of Gas Condensate Relative Permeability Using a Lattice Boltzmann Modeling Approach

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Predicting well deliverability loss due to condensate banking requires imbibition gas/oil relative permeability as a function of capillary number. These measurements can be difficult to conduct and are often unavailable. It would be of benefit if reasonable estimates of the imbibition relative permeability can be obtained from commonly available drainage data. We use a multiphase lattice Boltzmann method to compute drainage and imbibition gas/oil relative permeability for a Berea sandstone core. The computations are done on a 3D digital pore space of the core constructed for micro-CT-scan images. The imbibition calculations are for both displacement and dropout processes, and for a range of capillary numbers. These results are then compared to experimental measurements reported in the literature as a function of k_{rg}/k_{ro} and capillary number N_c, and they showed agreement with experimental results for different sandstones.

SCA2019-016. Low-Permeability Measurement on Crushed Rock: Insights

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The Gas Research Institute (GRI) method enabling permeability measurement on crushed samples or drill cuttings was proposed by Luffel et al. in the early 1990s. This paper presents a study led by Cydarex and Total to (1) analyze the validity of permeabilities determined with GRI methods applied in the industry, (2) collect information about these methods, and (3) explain the discrepancies between the results collected for similar rocks. Three materials were selected: one homogeneous outcrop rock and two reservoir rocks having absolute permeabilities ranging from 1 to 50 nD and anisotropy ratios varying from 1 to 3. For each rock, the permeabilities delivered by three commercial laboratories having their own GRI techniques were compared to the permeabilities we derived with the DarcyPress and Step Decay techniques. In addition to using different methods, the companies worked on diverse samples going from a plug of a few centimeters to a pack of millimeter-size particles. It was highlighted that the dispersion in the permeability data increases when the sample characteristic length decreases. To better understand the observations, the results were analyzed considering many things: literature, laboratories' crushed samples, laboratories' data and information, permeability values from GRI tests we undertook, numerical simulations…

SCA2019-017. Towards Relative Permeability Measurements in Tight Gas Formations

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Relative permeability is a concept used to convey the reduction in flow capability due to the presence of multiple fluids. Relative permeability governs multiphase flow, therefore it has a significant importance in understanding the reservoir behavior. These parameters are routinely measured on conventional rocks, however, their measurement becomes quite challenging for low-permeability rocks, such as tight gas formations.

This study demonstrates a methodology for relative permeability measurements on tight gas samples. The gas permeability has been measured by the step-decay method and two different techniques have been used to vary the saturations: steady-state flooding and vapor desorption.

A series of steady-state gas/water simultaneous injections has been performed on a tight gas sample. After stabilization at each injection ratio, NMR T_2, NMR Saturation profile and low-pressure step-decay gas permeability have been measured. In parallel, progressive desaturation by vapor desorption technique has been performed on twin plugs. After stabilization at each relative humidity level the NMR T_2 and step-decay gas permeability have been measured in order to compare and validate the two approaches.

The techniques were used to gain insight into the tight gas two-phase relative permeability of extremely low petrophysical properties (K<100 nD, ϕ < 5 p.u.) of tight gas samples of pyrophillite outcrop.

The two methods show quite good agreement. Both methods demonstrate significant permeability degradation at water saturation higher than irreducible. NMR T_2 measurements for both methods indicates bimodal T_2 distributions, and desaturation first occurs on

low T_2 signal (small pores).

Comparison of humidity drying and the steady-state desaturation technique has shown a 12 to 18 s.u. difference between critical water saturation (S_{wc}) measured in gas/water steady-state injection and irreducible saturation (S_{wirr}) measured by vapor desorption.

SCA2019-018. Storing CO_2 as Solid Hydrate in Shallow Aquifers: Electrical Resistivity Measurements in Hydrate-Bearing Sandstone

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A recent proposed carbon dioxide (CO_2) storage scheme suggests solid CO_2 hydrate formation at the base of the hydrate stability zone to facilitate safe, long-term storage of anthropogenic CO_2. These high- density hydrate structures consist of individual CO_2 molecules confined in cages of hydrogen-bonded water molecules. Solid-state storage of CO_2 in shallow aquifers can improve the storage capacity greatly compared to supercritical CO_2 stored at greater depths. Moreover, impermeable hydrate layers directly above a liquid CO_2 plume will significantly retain unwanted migration of CO_2 towards the seabed. Thus, a structural trap accompanied by hydrate layers in a zone of favorable kinetics is likely to mitigate the overall risk of CO_2 leakage from the storage site. Geophysical monitoring of the CO_2 storage site includes electrical resistivity measurements that rely on empirical data to obtain saturation values. We have estimated the saturation exponent, n in Archie's equation for CO_2 and brine-saturated pore network ($n \approx 2.1$), and for hydrate-bearing seal ($n \approx 2.3$ for SH < 0.4), during the process of storing liquid CO_2 in Bentheimer sandstone core samples. Our findings support efficient trapping of CO_2 by sedimentary hydrate formation and show a robust agreement between saturation values derived from PVT data and from modifying Archie's equation.

SCA2019-019. Multiphase Flow Imaging Through X-Ray Microtomography: Reconsideration of Capillary End-Effects and Boundary Conditions

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We focus on capillary end-effects and boundary conditions during multiphase flow experiments. To that extent, we performed drainage and imbibition experiments on Bentheimer plugs with various wettabilities and for various flow rates. For each case, we studied the fluid distribution inside the pore space by means of X-ray microtomography. Experimental observations focus on three main aspects: (1) fluid distribution in the diffusers, (2) saturation profiles and, (3) cluster dynamics near the outlet-end interface.

It is shown that there is always an end-effect near the last cm/mm which cannot be investigated by many routine SCAL devices. Furthermore, the outlet saturation varies significantly with flow rate, which disagrees the widely used zero capillary pressure (P_c) condition at the outlet corresponding to very little variation of the outlet-end saturation. In a standard configuration (inlet end piece–rock–outlet end piece) the observed filling states of the rock's interfaces contradict usual mathematical boundary conditions imposed on flow equations and the outlet end-piece may act (depending on geometry) as an obstacle to the flow direction thus generating perturbations and disturbing saturation profiles.

These experimental observations confirm the general conclusions that the physics of multiphase flow towards the boundaries in DRP and traditional SCAL experiments may be insufficiently known.

SCA2019-020. Local Capillary Pressure Estimation Based on Curvature of the Fluid Interface—Validation With Two-Phase Direct Numerical Simulations

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With the advancement of high-resolution three-dimensional X-ray imaging, it is now possible to directly calculate the curvature of the interface of two phases extracted from segmented CT images during two-phase flow experiments to derive capillary pressure. However, there is an inherent difficulty of this image-based curvature measurement: the use of voxelized image data for the calculation of curvature can cause significant errors. To address this, we first perform two-phase direct numerical simulations to obtain the oil- and water-phase distribution, the exact location of the interface, and local fluid pressure. We then investigate a method to compute curvature on the oil/water interface. The interface is defined in two ways. In one case the simulated interface which has a suresolution smoothness is used, while the other is a smoothed interface which is extracted from synthetic segmented data based on the simulated phase distribution. Computed mean curvature on these surfaces is compared with that obtained from the fluid pressure computed directly in the simulation. We discuss the accuracy of image-based curvature measurements for the calculation of capillary pressure and propose the best way to extract an accurate curvature measurement, quantifying the likely uncertainties.

SCA2019-021. Determination of Critical Gas Saturation by Micro-CT

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The critical gas saturation was directly determined using micro-CT flow experiments and associated image analysis. The critical gas saturation is the minimum saturation above which gas becomes mobile and can be produced. Knowing this parameter is particularly important for the production of an oil field that during its lifetime falls below the bubblepoint, which will reduce the oil production

dramatically. Experiments to determine the critical gas saturation are notoriously difficult to conduct with conventional coreflooding experiments at the Darcy scale. The difficulties are primarily related to two effects: (1) The development of gas bubbles is a nucleation process that is governed by growth kinetics that, in turn, is related to (2) the extent of pressure drawdown below the bubblepoint. At the Darcy scale, the critical gas saturation at which the formed gas bubbles connect to a percolating path, is typically probed via a flow experiment, during which a pressure gradient is applied. This leads not only to different nucleation conditions along the core but also gives no direct access to the size and growth rate of gas bubbles before the percolation. In combination, these two effects imply that the critical gas saturation observed in such experiments is dependent on permeability and flow rate, and that the critical gas saturation relevant for the (equilibrium) reservoir conditions has to be estimated by an extrapolation. Modern digital-rock-related experimentation and modeling provides a more elegant way to determine the critical gas saturation. We report pressure depletion experiments in minicores imaged by X-ray computed micro-tomography (micro-CT) that allowed the direct determination of the connectivity of the gas phase. As such, these experiments enabled the detection of the critical gas saturation via the percolation threshold of the gas bubbles. Furthermore, the associated gas and oil relative permeabilities can be obtained from single-phase flow simulations of the connected pathway fraction of gas and oil, respectively.

SCA2019-022. Inverted Bucket Centrifugation With Fluorinated Oils and its Applications to T_2 Cutoffs

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Hydrocarbon reservoirs with a large column height as well as tight gas rocks require a large range of capillary pressures to describe the saturation of fluids present in these formations. While mercury injection capillary pressure (MICP) can achieve high equivalent capillary pressures, the tests are destructive to the core plugs. Centrifuge techniques have gained in popularity since they are faster than the porous-plate technique, but they are limited in the achievable pressure range. Here, we propose the use of fluorinated oils to extend the achievable capillary pressure of the air-brine centrifuge technique by a factor of two. We use Fluorinert FC-70 in an inverted bucket configuration, which doubles the radius of rotation and keeps the density contrast comparable to an air-brine system. Furthermore, we show the application to NMR *T2* cutoff determination as a function of capillary pressure. Since Fluorinert does not contain any hydrogen, there is no signal overlapping with the brine in the core plugs. Furthermore, in the inverted bucket configuration, the outlet face of the plug is not in contact with a drainage surface so that the Hassler-Brunner boundary condition of $P_c = 0$ is satisfied. Additionally, the method allows the storage under a liquid Fluorinert phase, which prevents evaporation and significantly extends the available time for NMR measurements at low water saturations.

SCA2019-023, A New Apparatus for Coupled Low-Field NMR and Ultrasonic Measurements in Rocks at Reservoir Conditions

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Models that describe the effect of pore fluids on elastic-wave propagation in rocks are the basis for quantitative reservoir analysis. Laboratory ultrasonic measurements conducted on rock cores are often used to test the applicability of the various models and adapt them as required. Current saturation-wave velocity models usually require some description of fluid saturation and/or distribution, pore aspect ratio, wettability and fluid viscosity. These are often measured indirectly at different experimental conditions to the reservoir or simply assumed. Hydrogen (^{1}H) nuclear magnetic resonance (NMR) is a technique that can be used to quantitatively describe some of these important parameters. Here we report the design and performance of a novel NMR-compatible core-holder system allowing for the measurement of both ultrasonic P-wave velocities and NMR relaxation parameters in rock cores at reservoir pressure and at variable fluid saturation conditions. Successful validation against a conventional benchtop ultrasonic measurement system was performed using a dry Berea sandstone core, while sequential NMR and ultrasonic measurements were performed on a Bentheimer sandstone core at reservoir pressures and as a function of variable brine saturation (coreflooding conditions).

To the authors' knowledge, this new apparatus represents the first documented example of coupled high-temperature NMR and ultrasonic measurements conducted at the same experimental conditions on the same rock specimen, and allows for a new approach to study pore-scale saturation effects on elastic-wave propagation in rocks.

SCA2019-024. Defining a Sample Heterogeneity Cutoff Value to Obtain Representative Special Core Analysis (SCAL) Measurements

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We recently published a method to quantitatively assess a heterogeneity number *V* that indicates the variability of the absolute permeability in a core plug. At that time, however, we could not provide a suitable cutoff for *V*. Therefore, the risk remained that SCAL measurements could be conducted on samples with a local distortion dominating flow and water cut behavior. Subsequent use of the extracted relative permeability data in a reservoir simulation model would cause the field behavior to be dominated in the same way, generating significantly wrong forecasts.

In the present study, more than 70 scenarios for synthetic heterogeneous core plugs were simulated to study the impact of heterogeneity on flow parameters measured in SCAL experiments. Both unsteady-state and centrifuge experiments on these synthetic plugs were simulated in 3D. Subsequently, the simulated production data were history matched with a newly developed AutoSCORES software package to extract the relative permeability and capillary

pressure in an objective manner. A rigorous statistical analysis was applied to determine a cutoff value for the heterogeneity number *V* for each listed scenario. The cutoff proved to be strongly dependent on the number of samples available in a SCAL study. First experimental results of measurements on actual rock samples are in line with predictions. A table is presented to assist SCAL experimentalists in deciding which SCAL samples reliably can be used for a SCAL study unaffected by the effects of heterogeneities, based on *V* of a sample.

SCA2019-025. Digital Core Repository Coupled With Machine Learning as a Tool to Classify and Assess Petrophysical Rock Properties

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To make efficient use of image-based rock physics workflow, it is necessary to optimize different criteria, such as quantity, representativeness, size and resolution. Advances in artificial intelligence give insights of database potential. Deep-learning methods not only enable classification of rock imagees, but could also help to estimate their petrophysical properties.

In this study, we prepare a set of thousands of high-resolution 3D images captured in a set of four reservoir rock samples as a base for learning and training. The Voxilon software computes numerical petrophysical analysis. We identify different descriptors directly from 3D images used as inputs. We use convolutional neural-network modeling with supervised training using TensorFlow framework. Using approximately 15,000 2D images to drive the classification network, the test on thousands of unseen images shows any error of rock-type misclassification. The porosity trend provides a good fit between digital benchmark datasets and machine-learning tests. In a few minutes, database screening classifies carbonates and sandstones images and associates the porosity values and distribution. This work aims at conveying the potential of deep-learning method in reservoir characterization to petroleum research, to illustrate how a smart image-based rock physics database at the industrial scale can swiftly provide access to rock properties.

SCA2019-026. Using Capillary Condensation and Evaporation Isotherms to Investigate Confined Fluid Phase Behavior in Shales

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The abundance of nanopores (pores with diameters between 2 and 100 nm) in shale and ultratight reservoirs precludes the use of common pressure-volume-temperature (PVT) analyses on reservoir fluids. The small sizes of the pores cause capillary condensation, which is a nanoconfinement-induced gas-to-liquid phase change, that can occur at pressures more than 50% below the corresponding bulk phase change of the fluid due to strong fluid-pore wall interactions. We quantify this phenomenon by measuring propane isotherms both in a synthetic nanoporous medium and a core from a shale-gas reservoir. Comparison of our results in the two porous media indicates the occurrence of capillary condensation in shale rock. At the same time, we observe capillary condensation hysteresis for shale, in which the density of the fluid is significantly lighter during desorption than adsorption. This indicates structural changes to the rock matrix caused by the phase behavior of the confined fluid. We use scanning electron microscopy to corroborate our findings. These results have significant implications for determining the PVT properties, porosity, and permeability of shale and ultratight formations for use in reservoir modeling and production estimations.

SCA2019-027. Methane Isotherms and Magnetic Resonance Imaging in Shales

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Adsorption isotherms of light hydrocarbons on reservoir rocks are key data used to quantify the total gas content in reservoirs and isotherms are now being used to improve our understanding of the processes affecting subsurface gas flow associated with gas injection from enhanced oil recovery techniques.

This project combined elements of the traditional pressure-volume gas-adsorption isotherm technique and an NMR-based adsorption isotherm approach to determine the adsorption isotherms of light hydrocarbons on to tight rocks from oil and gas reservoirs. The new approach allows isotherms to be derived from NMR data. First, a T_2 distribution of the gas is determined over a range of gas pressures. Next, the volume of pore gas is estimated using the pore volume of the rock and the Van der Waals gas equation. The adsorbed gas content is then calculated by subtracting pore gas content from the total gas content. This is repeated for a range of gas pressures to determine the adsorption isotherm.

This project used the NMR method described above and measured the gas pressure decay in the NMR cell. This combined approach includes the advantages of the NMR method but it also produces a pressure-time curve that can be used to identify when equilibrium is attained in low permeability rocks and can be used to compare adsorption kinetics of different gases.

The advantages of our approach are that (1) the samples remain intact and the measurements provide information on the pore-size distribution, (2) analyses can be carried out at reservoir pressures, (3) isotherms can be measured for any gas containing hydrogen atoms, and (4) the results can be used to examine the processes controlling gas flow through the rock. Future work to develop this technique will improve our quantification of the amount of pore gas in the cell, which will improve our partitioning between adsorbed gas and pore gas as well as allow for an improved analysis of the pressure response of the sample after degassing.

SCA2019-028. Dielectric Polarization in Partially Saturated Shales

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Dielectric measurements of reservoir rocks are used to estimate important petrophysical properties, such as water-filled porosity and pore-surface textures. However, complex dielectric polarization processes that occur in rocks are strongly dependent on frequency, making physically meaningful interpretation of broadband dielectric data difficult.

Here, we demonstrate the application of Tikhonov regularization methods to compute dielectric relaxation-time distributions from broadband (40 Hz to 110 MHz) dielectric data for a shale sample at varying partial saturation. Furthermore, via the Kramers-Kronig relation the contribution from in phase conduction currents to the imaginary component of the dielectric response was quantified. The evolution of dielectric polarization processes with increasing moisture content was analyzed directly from changes in relaxation-time distributions. It was found that the dominant polarization mechanism up to a critical partial saturation occurred exclusively in the electrical double layer (EDL). Above this critical partial saturation electrodiffusion mechanisms acting between the diffuse layer and the bulk electrolyte controlled the low-frequency response. This work provides valuable insight into dielectric polarization mechanisms in shales, and demonstrates such measurements are sensitive to EDL properties and electrodiffusion length scales that are relevant to characterizing pore properties in shales.

SCA2019-029. CT-Scan In-Situ Investigation of Waterflood Front Instabilities During Immiscible Displacements: Effect of Viscosity Contrast and Flow Rate

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In this work, unstable displacements were conducted using special equipment designed to run in- situ CT-scanner experiments. All the displacements were conducted on a strongly water-wet Bentheimer sandstone full-size plug 10 cm in diameter and 40 cm in length. It was found that the oil recovery at brine breakthrough (%PV) shows a good correlation with the viscous fingering number as defined by Doorwar. Early water breakthrough appears to be boosted by high injection flow rate and less favorable fluids mobility ratio. The local saturation monitoring provides new insight to characterize the finger shapes and analyze the production mechanisms, for the different flowing conditions. In water-wet conditions, the capillary forces contribute to stabilize the front against viscous instabilities. If the viscous forces become too dominant, the capillary forces are overcome and fingering may occur for displacement with unfavorable fluids ratio. A diagram has been constructed to separately quantify the contribution of the viscous fingering and the capillary fingering. Results have shown that capillary fingering was the main mechanism responsible for the water early breakthrough.

SCA2019-030. Core-Scale Sensitivity Study of CO_2 Foam Injection Strategies for Mobility Control, Enhanced Oil Recovery, and CO_2 Storage

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This paper presents experimental and numerical sensitivity studies to assist injection strategy design for an ongoing CO_2-foam field pilot. The aim is to increase the success of in-situ CO_2-foam generation and propagation into the reservoir for CO_2 mobility control, enhanced oil recovery (EOR) and CO_2 storage. Unsteady state in-situ CO_2-foam behavior, representative of the near-wellbore region, and steady-state foam behavior was evaluated. Multicycle surfactant-alternating-gas (SAG) provided the highest apparent viscosity foam of 120.2 cP, compared to coinjection (56.0 cP) and single-cycle SAG (18.2 cP) in 100% brine saturated porous media. CO_2-foam EOR corefloods at first-contact miscible (FCM) conditions showed that multicycle SAG generated the highest apparent foam viscosity in the presence of refined oil (*n*-Decane). Multicycle SAG demonstrated high viscous displacement forces critical in field implementation where gravity effects and reservoir heterogeneities dominate. At multiple-contact miscible (MCM) conditions, no foam was generated with either injection strategy as a result of wettability alteration and foam destabilization in presence of crude oil. In both FCM and MCM corefloods, incremental oil recoveries were on average 30.6% OOIP regardless of injection strategy for CO_2 foam and base cases (i.e., no surfactant). CO_2 diffusion and miscibility dominated oil recovery at the core-scale resulting in high microscopic CO_2 displacement. CO_2 storage potential was 9.0% greater for multicycle SAGs compared to coinjections at MCM. A validated core-scale simulation model was used for a sensitivity analysis of grid resolution and foam quality. The model was robust in representing the observed foam behavior and will be extended to use in field-scale simulations.

SCA2019-031. New Laboratory Coreflooding Experimental System for EOR Surfactant Screening, Especially for Foam

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Coreflooding experiments are often used to assess the performance of EOR techniques or to screen surfactants. An inherent success factor of chemical EOR processes is the choice of the optimal surfactant, which is a trade-off between process performance and economic considerations. Currently, this trade-off can often not fully be evaluated with laboratory experiments because the associated experiments are time consuming, which typically limits their number and, in turn, impacts the reliability of the results. For this reason, we aimed to develop an automated and parallel coreflooding unit to conduct faster, cheaper and reliable tests for EOR technologies. The benefit of doing this is to dramatically increase the statistics of EOR-related experimentation while decreasing the manpower needed, leading to a much better value-to-cost ratio.

As a first step, we designed a setup which is applicable for multiple EOR-related coreflooding experiments, such as alkaline-surfactant polymer (ASP), low salinity, polymer flooding or foam

injection. The device can be used for co- or sequential injection of gas, water and oil. For the high-compressibility gas phase, it is often desirable to regulate its in-core volumetric flow rate. We control the gas flow using inline sensors and flow meters corresponding to the real-time in-situ core pressure. With a feedback loop, the offset of gas flow can be automatically updated within 0.1% deviation from the target setting. By miniaturizing the core sample and simplifying the experimental procedures, the automated flooding process achieved 90% efficiency gain while reducing sample consumption. This proof of concept can easily be further evolved into a parallelized system. Experience with this new coreflooding system demonstrated the dramatic increase in screening capacity and added value to the EOR development workflows.

SCA2019-032. A New CEC Measurement Proxy Using High-Frequency Dielectric Analysis of Crushed Rock

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Measuring the cation exchange capacity (CEC) of clay-bearing rocks is a useful tool to estimate smectite content, or the amount of swelling clay in the rock, and is referenced across many aspects of oil and gas exploration. Measuring the CEC of a rock, however, is laborious and, depending on the method used, requires saturation and extraction steps, the use of multiple chemicals, titration, and spectroscopic analysis.

This study, which builds on the established petrophysical link between clays and relative permittivity (ε'r), outlines a workflow and set of equations that allow for bulk rock CEC to be calculated from permittivity measurements of crushed rock using a handheld dielectric probe. A series of quartz-smectite mineral mixtures was prepared and high-frequency (80 MHz to 1.4 GHz) dielectric measurements collected at six relative humidity (RH) conditions ranging from 8 to 75%. For each RH dataset, a strong linear relationship ($R^2 \geq 0.98$) exists between permittivity at 120 MHz and the labooratory-measured CEC of the mineral mixtures. The equations from these calibration curves were used to derive three RH-dependent equations.

The method was validated on a variety of crushed sedimentary rocks and differences between the calculated values from this study and the lab-measured CECs range between ±6 meq/100 g. These results demonstrate that dielectric permittivity measurements can be used as a CEC-proxy and is a fast and flexible alternative to laboratory-based CEC analysis.

SCA2019-033. Gas Slippage in Partially Saturated Tight Rocks and During Drainage

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Effective gas permeability in partly water-saturated tight rocks is controlled by both, slippage and capillary effects. We present effective gas permeability coefficients measured on partially presaturated tight rock samples and during drainage starting from fully water-saturated samples. Measurements were made on Carboniferous (Westphalian D) and Permian (Rotliegend) tight sandstones with porosities <15% and permeability coefficients $<10^{-16}$ m² (0.1 mDarcy). Plugs of 30 to 38 mm in diameter and up to 40 mm in length were used in this study in "triaxial" flow cells. Confining pressures ranged from 15 to 40 MPa and differential gas pressures up to 11 MPa were applied. Drainage of initially water-saturated samples was monitored by nuclear magnetic resonance (NMR) in a flow-through cell. Additionally, gas flow experiments were run on samples with defined initial water saturations of up to 60%, established either by equilibration with water vapor or by centrifuging. Effective gas permeability coefficients increased by up to three orders of magnitude with decreasing water content. The experiments revealed that above a critical water saturation, the effective permeability coefficients depend on drainage- and imbibition-controlled re-distribution of the water phase. Below this critical water saturation, the apparent permeability coefficients of the gas are dominated by slippage effects.

SCA2019-034. Modeling Permeability in Carbonate Rocks

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In carbonate reservoirs, permeability prediction is often difficult due to the influence of various geological variables that control fluid flow. Many attempts have been made to calculate permeability from porosity by using theoretical and empirical equations. The suggested permeability models have been questionable in carbonates due to inherent heterogeneity and complex pore systems. The main objective of this paper is to resolve the porosity-permeability relationships and evaluate existing models for predicting permeability in different carbonate rock types.

Over 1,000 core plugs were studied from seen different carbonate reservoirs across the Middle East region. The plugs were carefully selected to represent main property variations in the cored intervals. The dataset available included laboratory-measured helium porosity, gas permeability, thin-section photomicrographs and high-pressure mercury injection. Plug-scale X-ray CT imaging was acquired to ensure the samples were free of induced fractures and other anomalies that can affect the permeability measurement. Rock textures were analyzed in the thin-section photomicrographs and were classified based on their content as grainy, muddy and mixed. Special attention was given to the diagenesis effects, mainly compaction, cementation and dissolution. The texture information was plotted in the porosity- permeability domain, and was found to produce three distinct porosity-permeability relationships. Each texture gave a unique poroperm trend, where the extent of the trend was controlled by diagenesis. Rock types were defined on each trend by detailed texture analysis and capillary pressure. Three different permeability equations (Kozney, Winland, Lucia) were evaluated to study their effectiveness in complex carbonate reservoirs. The texture-diagenesis based rock types provided more insight into the effects of geology on fluid flow and saturation. Available models may

not fully describe permeability in heterogeneous rocks but they can improve our understanding of flow characteristics in various rock types.

SCA2019-035. Direct Magnetic Resonance Measurement of Average Pore Size

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Magnetic resonance relaxation-time distribution measurements, notably T_2 measurement, are commonly employed as a proxy measurement of pore size. They are not direct measurements of pore size and may only be converted to pore size through a separate determination of a relaxivity.

In this work, we employ the Brownstein-Tarr interpretation of magnetic resonance relaxation to identify nonground modes of signal decay. These modes, most readily identified through a T_1-T_2 measurement, permit determination of an average pore size and surface relaxivities ρ_1 and ρ_2. Bulk pore-size measurements are reported for three different sandstones with average pore size confirmed by electron microscopy. The pore-size measurement may be spatially resolved with a spatially resolved T_1-T_2 measurement, implemented with an inversion recovery preparation for an SE-SPI T_2 mapping measurement. Spatially resolved pore-size measurements agree with bulk measurements.

SCA2019-036. Two-Phase Fluid Flow Experiments Monitored by NMR

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We present a newly developed high-pressure nuclear magnetic resonance (NMR) flow cell, which allows for the simultaneous determination of water saturation, effective gas permeability and NMR relaxation-time distribution in two-phase fluid flow experiments. We introduce both the experimental setup and the experimental procedure on a tight Rotliegend sandstone sample. The initially fully water saturated sample is systematically drained by a stepwise increase of gas (nitrogen) inlet pressure and the drainage process is continuously monitored by low-field NMR relaxation measurements. After correction of the data for temperature fluctuations, the monitored changes in water saturation proved very accurate. The experimental procedure provides quantitative information about the total water saturation as well as about its distribution within the pore space at defined differential pressure conditions. Furthermore, the relationship between water saturation and relative (or effective) apparent permeability is directly determined.

SCA2019-037. Transport Properties of the Cobourg Limestone: A Benchmark Investigation

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The Cobourg limestone formation is proposed as a possible repository site for nuclear waste in Canada. This limestone displays significant heterogeneity, characterized by light-gray calcite nodular regions, interspersed with dark-gray calcite-dolomite-quartz partings containing a clay component. Mineral composition is dominated by calcite, with some minor amounts of ankerite, illite/muscovite/I-S and quartz. Analysis of the pore structure shows that Cobourg limestone is extremely tight with porosities between 0.33 and 2.51%.

This paper aims at both a comprehensive description of the transport properties of the Cobourg limestone on the nm- to cm-range, and the comparison of different experimental techniques: gas measurement using decay, quasistatic, or steady-state methods. In total, four labs measured permeability, porosity and analyzed the pore system by various methods (micro-CT, BIB/SEM). In all flow experiments, slip flow was accounted for by means of the Klinkenberg correction.

The effects of pore pressure, confining pressure, sample size and coring orientation are studied. For all laboratories, results range from 100 microdarcies to 1 nanodarcy. Even for a given laboratory, results are comprised in a broad range, with several orders of magnitude differences depending on coring direction, confining pressure and sample size. Flow occurs through slit-shaped pores/fractures, which are orientated along heterogeneities. Upon loading, these natural and/or artificial pores successively close, resulting in a reduced permeability and stress sensitivity.

Results are dominated by heterogeneity and anisotropy of the Cobourg limestone, so that it is delicate to select one method over another. Rather, each brings useful information to better understand this low-permeability and low-porosity natural material.

SCA2019-038. Pore-Scale Experimental Investigation of In-Situ Wettability and Displacement Mechanisms Governing WAG in Oil-Wet Carbonates

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In oil-wet carbonates, due to low oil production through conventional waterflooding, water-alternating-gas (WAG) injection is deployed to enhance oil recovery. However, to-date, there is a lack

of fundamental understanding of the underlying physics governing the flow at the pore scale during WAG. The advent of advanced X-ray microtomography (micro-CT) technology provides opportunities to study this complex displacement process at the pore level.

In this study, a series of miniature coreflooding experiments were performed at elevated temperature and pressure conditions, using a highly-accurate coreflooding system integrated with a high-resolution micro-CT scanner. Miniature core samples were subjected to a dynamic wettability alteration process (aging) with crude oil followed by three cycles of WAG injection. The samples were X-ray imaged to generate three-dimensional fluid occupancy maps during different two- and three-phase flow stages of the WAG cycles. Pore-scale displacement mechanisms governing WAG EOR under oil-wet conditions were examined by analyzing the pore-fluid occupancy maps. The results showed that the WAG flooding scheme significantly enhanced oil recovery. The sweep efficiency of both gas and brine phases were increased due to the shielding effect of the trapped gas ganglia. Oil production diminished rapidly after two waterflooding and gas injection cycles.

SCA2019-039. High-Resolution In-Line Density Measurements: Insight on Multiphase Flow and Transport Phenomena in Porous Media

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An in-line densitometer is used in coreflooding applications to quantify fluid production from core samples and obtain quantitative and qualitative information, such as connate water production, breakthrough times, emulsion/foam generation, and steam condensation.

A series of corefloods was performed with a densitometer placed at the outlet of a sandpack. All fluids passed through the measurement cell at experiential temperatures and pressures. The second series of tests was performed at high temperature and pressure, with a densitometer placed at the inlet and outlet of a sandpack, for steam applications. In both series of experiments, data acquisition was collected at 1 Hertz and the analyzed density data was compared to results from the conventional effluent analysis, including Dean-Stark, toluene separations, magnetic susceptibility measurement, and flash calculations where applicable.

The high-resolution monitoring of effluent from a flow experiment through porous media in a system with two phases of known densities enables two-phase production to be accurately quantified in the case of both light and heavy oil. The frequency of measurements results in a high-resolution history of breakthrough times and fluid behavior. In the case of monitoring steam injection processes, reliable laboratory tests show that in-line density measurements enable the determination of steam quality at the inlet and outlet of a sandpack and qualitative determination of steam condensation monitoring.

The use of in-line densitometry in coreflooding applications provides insight on monitoring of complex fluid flow in porous media, which typical bulk effluent analysis is not able to do. The ability to measure produced fluids at high resolution and extreme temperatures reduces mass balance error associated with the effluent collection and broadens our understanding of complex fluid flow in porous media.

SCA2019-040. Pore-Scale Experimental Study of Carbonated Water Injection in an Oil-Wet Carbonate: An Improved Insight Into Wettability Alteration and Displacement Mechanisms

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Carbonated water injection (CWI) has been proposed to mitigate the poor sweep efficiency of conventional CO_2 flooding. Furthermore, CWI requires much less CO_2 that makes it more attractive for EOR projects that have access to limited quantities of CO_2. Even though previous experimental studies have presented data supporting the effectiveness of CWI for enhanced oil recovery, the direct evidence obtained from naturally occurring rock samples on pore-scale displacement mechanisms responsible for the observed recovery enhancements are scarce. In the past decade, X-ray microtomography (micro-CT) technology has become more readily available and this has created numerous opportunities for pore-level investigations of complex multiphase flow processes in natural porous media.

In this study, we probed the displacement mechanisms taking place during CWI and subsequent depressurization processes through miniature coreflooding experiments at elevated pressure and temperature conditions (1,400 psi and 50°C), using a HPHT coreflooding system integrated with a high-resolution micro-CT scanner. The miniature core sample was dynamically aged with crude oil at initial water saturation and subsequently subjected to waterflooding, CWI, and a depressurization step. The sample was repeatedly imaged using the micro-CT scanner in the course of the experiments. The images were then processed to generate three-dimensional fluid-occupancy maps from which the fluid saturations, in-situ contact angles, and local displacement patterns were determined. The results showed a significant incremental oil recovery due to CWI and subsequent depressurization steps compared to the unadulterated waterflooding. In-situ contact-angle measurements yielded direct evidences of wettability alteration from oil-wet to neutral-wet conditions during CWI. Our observations indicated that the wettability alteration was a gradual process, which facilitates oil displacement from the medium. The swelling of oil during CWI and the displacements taking place during the subsequent depressurization process also contributed to oil production.

SCA2019-041. The Digital Rock Analysis of Biogenically Induced Reservoir Heterogeneities in Cretaceous Reservoirs of Saudi Arabia

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The characterization of the fluid-flow properties in biogenically altered formations is a key for successful exploration campaigns. This study assessed reservoir quality and evaluated permeability of the biogenically-modified Cretaceous upper Ratawi section in Saudi Arabia. When dealing with these bioturbated carbonates, characterization of sedimentary heterogeneities is often overprinted by the complex spatial geometries of burrows. The high-resolution

3D X-ray microscopy imaging and analysis of these bioturbated sections lead to a better understanding of the interconnectivity between permeable burrows and tight matrix. The analysis deploys multiscale imaging from whole core to submicron scale. The coarse imaging at 20- to 50-µm resolution helped to identify bioturbated sections to select samples for higher resolution tomography. The 3D sample tomograms were segmented to define burrows and matrix distributions, where samples were extracted for thin sections, scanning electronic microscopy (SEM) and mercury injection capillary pressure (MICP) analyses to refine the pore sizes and rock types. The analysis showed an intricate, highly connected, mixed horizontal and inclined burrow system dominated by *Thalassinoides*. Intergranular porosity, associated with the fill of *Thalassinoides,* constitutes a mechanism for permeability enhancement in a tight matrix. Increased permeability is associated with higher dolomite content that might be used as a sweet spot identifier from wireline logs.

SCA2019-042. Novel Technique to Measure Mutual Bulk Fluid Diffusion Using NMR 1D Gradient

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Many modeling and theoretical studies have shown that diffusion can be a significant transport mechanism in low-permeability porous media. Understanding the process allows engineers to better predict reservoir performance during both primary production and enhanced recovery in unconventional reservoirs. Direct measurement of effective diffusion in tight rocks is difficult, due to small pore volumes and the lack of techniques to actually monitor the process. Conventional diffusion measurements generally require fluid sampling, which induces a pressure transient that changes the mass transfer mechanism. Previously, we introduced a novel technique to measure tortuosity in nanoporous media by simultaneously monitoring methane versus nitrogen concentrations at high pressure using transmission infrared spectroscopy (IR). To complete the estimation of effective diffusion, bulk-fluid diffusion coefficient also needs to be measured.

In this study, we demonstrate the usage of nuclear magnetic resonance (NMR) 1D imaging to examine the dynamic change of hydrogen index (HI) across the interface between two bulk fluids. The experiment was conducted between a crude-oil sample and methane; fluid samples were pressurized within an NMR transparent ZrO_2 pressure cell, which operates at pressures up to 10,000 psi. The HI profile was continuously measured and recorded for 7 days. The results provided oil the swelling factor and the concentration profile as a function of both time and distance. These data then were fitted with Maxwell-Stefan equation to precisely back-calculate the diffusion coefficient between oil and gas samples at high pressure. Accurate estimation of tortuosity and fluid diffusion is critical for the gas-injection strategy in a shale formation. Greater tortuosity and smaller fluid diffusion rates lead to longer injection and production times for desirable economic recovery.

SCA2019-043. A Surface Complexation Model of Alkaline-Smart Water Electrokinetic Interactions in Carbonates

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Understanding the effect of injection-water chemistry is becoming crucial, as it has been recently shown to have a major impact on oil recovery processes in carbonate formations. Various studies have concluded that surface charge alteration is the primary mechanism behind the observed change of wettability towards water-wet due to smartwater injection in carbonates. Therefore, understanding the surface charges at brine/calcite and brine/crude oil interfaces becomes essential to optimize the injection-water compositions for enhanced oil recovery (EOR) in carbonate formations.

In this work, the physicochemical interactions of different brine recipes with and without alkali in carbonates are evaluated using a surface complexation model (SCM). First, the zeta-potential of brine/calcite and brine/crude oil interfaces are determined for smartwater, NaCl, and Na_2SO_4 brines at fixed salinity. The high-salinity seawater is also included to provide the baseline for comparison. Then, two types of alkali (NaOH and Na_2CO_3) are added at 0.1 wt% concentration to the different brine recipes to verify their effects on the computed zeta-potential values in the SCM framework. The SCM results are compared with experimental data of zeta-potentials obtained with calcite in brine and crude oil in brine suspensions using the same brines and the two alkali concentrations. The SCM results follow the same trends observed in experimental data to reasonably match the zeta-potential values at the calcite/brine interface. Generally, the addition of alkaline drives the zeta-potentials towards more negative values. This trend towards negative zeta-potential is confirmed for the smartwater recipe with the impact being more pronounced for Na_2CO_3 due to the presence of divalent anion carbonate $(CO_3)^{-2}$. Some discrepancy in the zeta-potential magnitude between the SCM results and experiments is observed at the brine/crude oil interface with the addition of alkali. This discrepancy can be attributed to neglecting the reaction of carboxylic acid groups in the crude oil with strong alkalis, such as NaOH and Na_2CO_3.

The novelty of this work is that it clearly validates the SCM results with experimental zeta-potential data to determine the physicochemical interaction of alkaline chemicals with smartwater in carbonates. These modeling results provide new insights on defining optimal smartwater compositions to synergize with alkaline chemicals to further improve oil recovery in carbonate reservoirs.

SCA2019-044. Effects of Gas Pressurization on the Interpretation of NMR Hydrocarbon Measurements in Organic-Rich Shales

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The estimation of total hydrocarbons (HCs) in place is one of the most important economic challenges in unconventional resource plays. Nuclear magnetic resonance (NMR) has proven to be a valuable tool in directly quantifying both hydrocarbons and brines in the laboratory and the field. Some major applications of NMR interpretation include pore-body size distributions, wettability, fluid types, and fluid properties. However, for tight formations, the effects of the factors on NMR relaxation data are intertwined. One purpose of this study is to review the interpretation of NMR response of HCs in a tight rock matrix through illustrated examples.

When comparing NMR data between downhole wireline and laboratory measurement, three important elements need to be considered (1) temperature differences, (2) system response differences, and (3) pressure (mainly due to the lost gasses.) The effect of temperature on HCs would be presented with experimental results for bulk fluids. Whereas, the effect of pressure is investigated by injecting gas back into rock matrix saturated with original fluids. The experiments were performed within an NMR-transparent Daedalus ZrO_2 pressure cell which operates at pressures up to 10,000 psi.

The results show that at ambient temperature and pressure, NMR responds to a fraction of HCs which is volatile enough to be observed as an NMR relaxation sequence. The invisible fraction of HCs to NMR sequence at ambient condition can be up to 20% of the total extractable HCs. Molecular relaxation is impacted by fluid viscosity, pore size, and surface affinity. In other words, the fluid with higher viscosity (either due to temperature or gas loss), presenting in smaller pores, or highly affected by the pore surface, will relax faster, and would be partially invisible to NMR, especially in the field. This is critical to the interpretation of NMR response for liquid-rich source rocks, in which all of the above molecular relaxing restrictions can be found. Thus, engineers can underestimate movable HCs by using routine core analysis data.

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Abstracts

Invited Talk 1. Research Progress and Challenges Towards Commercial Gas Production From Methane Hydrate

Yoshihiro Masuda[1]
[1]University of Tokyo

Invited Talk 2. Tomakomai CCS Demonstration Project: Project Overview and Results to Date

Shoichi Fueki[1]
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Paper A. Estimating Geothermal Reservoir Characteristics by Using Landsat 8 Satellite Imagery Data: A Case Study in Mount Tangkuban Perahu Area, West Java, Indonesia

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The needs of the world for electricity, especially in Indonesia, is increasing along with population growth, consumerism, and technological advances. Furthermore, to fulfill the needs of electrical energy in Indonesia, which still relies heavily on fossil energy use, might cause many losses, especially to the environment. Geothermal energy is one of the renewable forms of energy and the right choice in today's global sustainable development due to low carbon emissions. Indonesia has 40% of all geothermal potential in the world with potential resources of 11,073 megawatts (MW), reserves of 17,506 MW, and the total energy of 28.579 gigawatts (GW).

Geothermal energy potential in Indonesia is widespread in areas that are traversed by the "ring of fire" or areas with active volcanic activity, one of them is Mount Tangkuban Perahu in West Java. The surface geothermal potential has been known from surface manifestations, which appear in the form of fumaroles, hot springs, mud pools, steaming ground, sinter, kaipohan, and hydrothermal alteration. If there are surface temperature anomalies, they could be identified as manifestations. It is possible to identify areas that have the potential of geothermal energy based on their surface relief through remote sensing. Identification of anomalies obtains through the processing of Landsat 8 satellite imagery using thermal bands 10 and 11 with thermal infrared (TIR) sensors. Remote sensing is very effective in identifying manifestations and potential of geothermal energy because it can cover data on a wide area, time, and cost efficiency. In addition to fluid manifestations, remote sensing can also identify the distribution of minerals in an area to estimate the reservoir characteristics of a geothermal system.

This study aims to estimate the geothermal reservoir characteristics in Mount Tangkuban Perahu area that used as an initial consideration in geothermal exploration and further geothermal research in other areas. The methods use in this research are split-window algorithm (SWA) to find the distribution of manifestations, calculations of radiative heat flux (RHF) to obtain an estimation of geothermal resource potential, and supervised classification method (SVM) to identify the distribution of the minerals. The results will provide information about surface temperature and heat losses based on anomalous manifestations, estimation of power electricity resource, lineament, and a conceptual model of Mount Tangkuban Perahu geothermal system.

Paper B. A Numerical Simulation Study on the Feasibility of a Use of Mini-Frac Test and AE Monitoring for the Delineation of Preexisting Permeable Faults/Fractures

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The objective of this study is to discuss the feasibility of a new use of the combination of mini-frac test and acoustic emission (AE) monitoring for the identification and delineation of preexisting faults/fractures with exceptionally high permeability in the vicinity of the well. In particular, geothermal field exploration often targets such natural fault/fracture zones, because of the high permeability expected based on the assumption of open fracture aperture, which is favorable for large amounts of steam production. However, the drilling success rate is only around 30%, which could result from the limited spatial resolution of the conventional geophysical exploration methods used in geothermal development, such as the gravity, resistivity and magnetic methods. More accurate exploration methods for permeable fault/fracture delineation are required.

Mini-frac tests have been widely conducted in oil, gas and/or geothermal field, which are mainly aimed to measure some kinds of initial state in the target formation, such as in-situ stress and pore pressure, usually before the massive hydraulic fracturing operation. Furthermore, if AE was monitored during the mini-frac test, the spatio-temporal hypocenter distribution could potentially help to estimate the dynamic behaviors of fracture extension or pressure diffusion. However, a relationship between the spatio-temporal hypocenter distribution and the existence of high permeable fault zones is not clearly understood. For an instance, aseismic zones show high permeable fault zones or not. This is because complex factors, such as pumping rate, pumping volume, fluid-flow capacity of the path from well to the permeable fault zones and fluid-flow capacity of the permeable faults themselves are mutually affected.

In this study, parameter sensitivity tests on some sets of pumping parameters and geological parameters are conducted using a numerical fracturing simulator "SHIFT". The simulation model was constructed based on actual field data acquired at the Hijiori Hot Dry Rock (HDR) site, Japan, and also some uncertain parameters are carefully tuned by matching the simulated fracturing pressure to the actual pressure response observed while the hydraulic fracturing operation conducted at the site. Consequently, the numerical simulation test suggested that the pressure diffusion arrival at the target fault with a certain range of permeability could be detected by drastic pressure drop and the occurrence of a series of AE events along the fault. These observations could make it possible to

identify the preexisting exceptionally permeable faulted/fractured structures.

Paper C. Development of Geothermal Reservoir Simulator for Predicting Water-Steam Flow Behavior Considering Nonequilibrium State and MINC/EDFM Model

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Although the reservoir simulation is widely used to predict geothermal reservoir performances, the results of the simulation are sometimes different from those actually observed in field operations due to nonequilibrium conditions and poor modeling of fracture system. For example, the recharge water sometimes reaches producing wells much earlier than predicted by reservoir simulation. Therefore, in this research, we attempted to develop a numerical simulator that can deal with the nonequilibrium vaporization of water and condensation of steam for predicting geothermal reservoir performances more accurately. We also attempted to construct a model that can rigorously express the main flow paths, such as faults and/or large-scale fractures.

First, we developed a three-dimensional simulator that can predict the flow behavior of geothermal fluids in the nonequilibrium state. Conventional geothermal simulators solve only the material balance equation for all the water molecules regardless of the phase condition. On the other hand, in the simulator developed in this research, water molecules in the liquid phase are distinguished from those in vapor phase, and two material balance equations are derived separately for water and steam. These equations have the terms to express the molecular transportation from steam to water and vice versa. Nonequilibrium vaporization and condensation of water molecules are expressed by adjusting the kinetic rate of transportation of water molecules across phases.

Next, we expanded the functions of the above simulator, incorporating two types of double porosity models, Kazemi and MINC, and EDFM (embedded discrete fracture model), to reproduce the fluid flow preferentially through fractures and faults. EDFM is the discrete type of fracture model assuming non-neighboring connections with regular grid, and is useful to calculate the flow through narrow paths even if their apertures are small and/or their directions are not parallel to the grid surface. After verifying the simulator functions, we investigated how the nonequilibrium condition and fracture properties affected the geothermal reservoir performances, especially those with recharging water. Case studies revealed that the nonequilibrium condition hastened the movement of the water injected as recharge water through fractures, which resulted in the water breakthrough earlier than predicted by conventional (equilibrium type) simulators. Case studies also suggested that it was crucial to appropriately estimate fracture properties through the history matching by using ILHS method because fractures are a main path for fluid flow. Finally, we concluded that this simulator could successfully handle the fluid flow through faults/fractures which improved the reliability of prediction.

Paper D. Preliminary Investigation of the Hydraulic Stimulation for a Field-Scale FORGE Candidate Geothermal Reservoir

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In order to develop, test, and improve technologies and techniques for the creation of sustainable EGS (enhanced geothermal systems), the FORGE (Frontier Observatory for Research in Geothermal Energy) project has been led by U.S. Department of Energy. Since the abundant datasets for both geology and geophysics are available, we can prepare the conceptual 3D geologic model by integrating them. In this study, we report the preliminary results of numerical simulation on the hydraulic stimulation response at this candidate site. We first design the discrete fracture network for the region of 1,200×800×800 m volume, which includes approximately 2,000 fractures. Then we explore the responses during hydraulic stimulation via the "SHIFT"-based simulator. A series of stimulations are performed in six stages/zones along the horizontal well and both low (5 kg/s) and high (80 kg/s) injection rates are specified in order. In our simulations, the ratio of stimulated (slipped / sheared) fractures volume to total volume of preexisting fractures is evaluated to be 1 to ∼2%. On the other hand, this parameter has been evaluated to be 10 tp ∼20% by the U.S. group, who adopt a DEM (distinct element method)-based simulator. Such a large discrepancy may be attributed to whether the propagation of newly created fractures is adequately taken into consideration or not.

Paper E. Supercritical Carbon Dioxide Fracturing of Granite From Conventional to Superhot Geothermal Conditions

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Our previous studies on fracturing in granite at 200 to 450°C under triaxial stress condition revealed that infiltration of low-viscosity supercritical water stimulates preexisting fractures and creates dense fracture networks which is favorable for enhanced extraction of geothermal energy. Presently, fracturing experiments have been carried out at similar conditions to examine feasibility of supercritical CO_2 adoption having low viscosities, for application at various geothermal conditions.

Fracturing experiments were conducted on cylindrical Inada Granite samples at 200 and 450°C, with a range of differential stress, where supercritical CO_2 was injected at 1 mL/min. At 200°C, 90 MPa axial stress and 40 MPa confining stress were applied. Meanwhile at 450°C, 90 Mpa axial stress with 40 or 25 MPa confining stress was applied. As a result, 50 MPa breakdown pressure was observed at 200°C. At 450°C, 47 and 16 MPa of breakdown pressure were observed for the experiment with 40 and 25MPa confining stress, respectively. As the theory predicted that in the case of nonpenetrating fluid, breakdown pressure will be approximately twice the magnitude of confining stress, these low breakdown pressures indicated fluid penetration. Furthermore, borehole pressure profiles suggested that pore pressures were close to borehole pressure. In addition, X-ray CT on the samples revealed that complex fracture patterns were developed.

It has been discovered that in this study, stress state at breakdown events are close to Griffith's fracture criterion. The low viscosity of supercritical CO_2 has allowed stimulation of preexisting fracture so that the rock failed in accordance with Griffith's theory,

in which fractures are generated in various directions involving extensional, extensional-shear, and shear modes. Hence, favorable complex fracture patterns were generated. These experimental results demonstrate the possibility of supercritical CO_2 use to replace water in fracturing application at wide range of geothermal conditions, due its capability to return low breakdown pressure, induce a dense fracture network, as well as to sequester CO_2, at least to some extent, at the same time.

Paper F. Well-Log Analysis for Surveying Optimum CCS Reservoir Location: A Case Study

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In CCS (carbon dioxide capture and storage) reservoir surveys to select optimum location, the capability and capacity of CO_2 gas storage of subsurface aquifer formations are major properties of concern. Target intervals extend from permeable reservoir rocks to top seal formations. As the reservoir generally covers the extended aquifer area, accurate formation evaluation using well data in existing nearby wells for judging to select candidate field is indispensable. Well-log interpretation conducted for the representative wells drilled offshore Japan will be introduced as a case study. The wells were drilled in the 1990s for surveying the potential of deeper hydrocarbon accumulation, and a sufficient suite of conventional logs and geological information are available. The CCS target reservoir zones consist of sandstone, volcanic tuff and silty mudstone deposited as turbidites at different stage and sedimentary environment in the regional post-uplift stage. The following are the contents of preliminary well survey: (1) facies and depositional environment, (2) shale and grain matrix properties, (3) shaly sand or thin-bed sand analysis and porosity, (4) permeability, (5) net reservoir, and (6) well ties with seismic reflection data. Proposals for new data acquisition are to be included for future test wells.

Paper G. A New Measurement of Evaluating Gas or CO_2 in Formations—Fast-Neutron Cross Section

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Many logging services and methodologies have been applied to evaluate gas (or CO_2) in formation in past decades. Measurements of resistivity, acoustic, thermal- or epithermal-neutron porosity, neutron capture, bulk density and NMR are mostly used. Of these some are used in open hole only while some can be run in cased hole but with limitations due to downhole environments or formation properties.

In recent years a new formation property, the fast-neutron cross section (FNXS), was introduced in the industry. It is an independent measure of the formation's ability to interact with fast neutrons, which physically is proportional to the total atom numbers in unit volume of formation. It can be measured in cased or open hole, it is sensitive to gas and effective for differentiating gas or CO_2 from rock matrix or pore fluids, such as oil and water.

In this paper we first review the approaches often used for gas evaluation and briefly introduce the FNXS. With a forward formation model simulating shaly tight sand, we analyze the effectiveness and sensitivity of FNXS to gas, as well as the effect on saturation resulting from possible error in porosity or shale volume. Field case studies are presented in the paper, showing three ways to interpret gas in the formation with the help of FNXS: quick look of FNXS overlaid with other logs, crossplotted in chart, and quantitative gas volume calculation with linear volume models. The feasibility of FNXS monitoring CO_2 in EOR or CCS projects is also discussed

Paper H. Well-Log Analysis for Methane Hydrate Saturation Evaluation—High-Resolution and Rock Physics

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Petrophysical formation property evaluation is the essential for any type reservoir characterization workflow including a methane hydrate (MH) reservoir. The conventional workflow is sometimes diffult to apply tos MH formations because the unique characteristic of MH deposition. Archie's law with resistivity measurement has been widely used and a NMR-based method is another well-known approach for evaluation of MH saturation. There is always uncertainty coming from the limited vertical resolution and the quality of measurement due to hole conditions. Thus, we have attempted to evaluate MH saturation in the study area using other approaches: (1) Formation resistivity derived from borehole image logs to understand MH saturation in high resolution, and (2) formation sonic log based on the rock physics model. A part of the MH formation consists of fine-grained, thinly bedded, silty sandstones, and siltstone that were deposited in a turbidite setting in the study area. The conventional resistivity log is affected by the thickness of layers, which is less than the vertical resolution of measurements. To overcome this challenge, we derived a high-resolution formation resistivity log from the processed borehole image log and succeeded to reasonably evaluate thee MH saturation of each layer. The result showed higher MH saturation in thinly bedded formations and is consistent with results in the relatively thick formation compared with results from conventional resistivity logs. The acoustic property of MH is faster than the formation fluid, because MH is deposited in the state of ice-like hydrocarbon under in-situ conditions. Thus, the sonic well log shows relatively fast where MH is deposited. Prevously, several rock physics models had been proposed for MH formations.

In this study, we used the simplified three-phase Biot-type equation and succeeded to evaluate MH saturation using the sonic log. The constructed rock physics model will be a key input for further seismic-scale rock physics study. This study was conducted as a part of the activity of the Research Consortium for Methane Hydrate Resources in Japan [MH21 Research Consortium] as planned by the Ministry of Economy, Trade, and Industry (METI), Japan.

Paper I. Development of Numerical Simulator for Predicting Oil Recovery by Low-Salinity Waterflooding, Taking Various Mechanisms Into Consideration

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Today, low-salinity waterflooding (LSWF), which injects water of low salinity, ranging from 1,000 to 5,000 ppm (LSW), into a reservoir, is attracting attention as one of the enhanced oil recovery (EOR) technologies. Since this method is environmentally friendly and its capital and operational costs are lower than those of other EOR methods, a variety of research has been attempted to elucidate LSWF. Decisive theory, however, has not been established yet due to the complexity of LSWF. So, we tried to develop a numerical simulator that enables us to reproduce the LSWF process, aiming at the rigorous investigation of the mechanisms of LSWF through numerical simulation.

Prior to developing the simulator, we focused on some mechanisms proposed on LSFW, especially on the cation exchange as one of the main contributors. In sandstone reservoirs, as LSW is injected into a reservoir, the concentration of cations in water phase decreases, and then the cations, especially Ca^{2+} combining with polar-oil, originally adsorbed on the clay minerals begins to be replaced with H^+. Along with the detachment of Ca^{2+}, polar-oil is also detached from the clay surface and the rock wettability changes from oil-wet to water-wet. Furthermore, the increase in differential pressure was observed during LSWF in past coreflooding experiments, which may have been caused by wettability alteration and fine/microemulsion migration. In contrast, in carbonate reservoirs, crude oil is directly attached on the rock surface because it is positively charged. Along with LSWF, the adsorption of the SO_4^{2-} ion is promoted and hence ionic bonds between crude oil and rock surface are cut off, which results in the recovery of additional oil.

We developed a pseudo-multicompositional simulator, which can deal with 1D, three-phase (oil, water and solid) and 19-component (nonpolar oil, polar oil, sand, H_2O, NaCl, $CaCl_2$, $MgCl_2$, H_2CO_3, $CaCO_3$, $MgSO_4$, H^+, Na^+, Ca^{2+}, Mg^{2+}, OH^-, SO_4^{2-}, Cl-, HCO^{3-}, CO_3^{2-}) problems, for accurately predicting the oil recovery by LSWF in both sandstone and carbonate reservoirs. The functions to calculate chemical reactions (ionization), adsorption/desorption of ions, diffusion of cations and fine migration were also incorporated. After developing this simulator, we verified the functions of this simulator comparing the simulation results with analytical solutions and/or those by commercial simulator. Then the results of past coreflooding experiments were successfully reproduced using this simulator. This study revealed that the cation exchange, wettability alteration and mineral dissolution were the key mechanisms in LSWF.

Paper J. Applicability of Low-Salinity EOR to an Offshore Clastic Reservoir in Vietnam Through Experiments and Simulation

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Low-salinity EOR has emerged as a cost-effective and an environmentally friendly EOR technique. However, there is no consensus about the definitive mechanism of the EOR effects even though a lot of researchers have been trying to clarify it because the dominant mechanisms might strongly depend on the properties of oil, water and rocks. Also, there are only a few papers referring how to conceptually evaluate the feasibility of low-salinity EOR at the full-field scale based on the laboratory and simulation studies. Therefore, this paper presents the case study of the field application of low-salinity EOR for the clastic reservoir integrating laboratory tests, field-scale reservoir simulation and facility design. In the laboratory tests part, three coreflood experiments by tertiary low-salinity water (LSW) injection were conducted with the stock-tank oil, reservoir cores and the synthetic waters. Consequently, 2 to ~17% of additional recovery factor (RF) were achieved with the differential pressure (DP) compared to the secondary high-salinity water (HSW) injection. In terms of chemical reactions, the divalent cation concentration in effluent was lower than that of injected water while monovalent cation concentration increased in all cases. In addition, pH increased by one unit compared to that of injected water with the appearance of emulsions. These experiments and the pore-size distribution from NMR suggest that the emulsification is the key to clarify the EOR effect in this reservoir.

At the first step of the simulation study, the LS relative permeability curves acquired from coreflood experiments were assigned to the black-oil reservoir model, on which the EOR effect, such as RF and DP, during the tests were reflected guided by the permeability distribution. Besides, the water treatment capacity of the desalination plant proposed previously, which is composed by reverse osmosis (RO) and nanofilter (NF) membrane in parallel, were considered as the simulation constraint. As a result, 3.5% of RF was achieved comparing to the HS case in the secondary recovery, but only 0.4% of RF over the HS case was increased with the constraint of water-treatment capacity. This result suggests that installationl of the desalinating system to the existing platform, the extension of platform and facilities, such as water intake system, is significantly important. This paper will provide not only the EOR mechanism by LSW from the unique point of view but also the conceptual feasibility study of this EOR technique for the offshore fields.

Paper K. First Field Test of the Dual Core-Bit Tool for Drilling Stress-Record Cores at Kamioka Mine, Japan

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We have developed a tool to drill core samples that records in-situ stress information around a bottom of a borehole. When the core is cut from the bedrock, it is released from the in-situ stress and expands slightly in the radial direction. Using this principle, the in-situ stress can be determined from the elliptical shape of the core cross section. However, the difference between major and minor axes of the ellipse only provides the difference between the maximum and the minimum in-situ stresses, and the magnitude of each cannot be determined. This is because the core diameter d0 before expansion is unknown. To solve this problem, we proposed a coring procedure using the “dual-core-bit tool” so that the shape before expansion is retained in part of the core. That is, after digging a groove (outer groove) in the borehole bottom by the outer core-bit, a smaller diameter core is cut by the inner core-bit in the same way as normal coring. As a result, the shape before expansion remains in the upper part of the core, and the shape should expand due to stress relief in the lower part deeper than the outer groove.

According to this concept, we made a prototype of the dual-core-bit tool and conducted the first field test at Kamioka mine in Gifu, Japan. This paper describes the mechanism of the tool and the results of the field test.

Paper L. Continuous Depth Profile of Rock Strength Along a Borehole Based on Drilling Performance Parameters

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In-situ rock strength with depth under the ground/seafloor is a critical parameter for various studies in resources exploration, geology and seismology. The measurements on rock/core samples, however, have been hardly done with success due to the lack of drilled cores and sufficient knowledge about the in-situ conditions, such as pressure and temperature. We proposed a new indicator of the strength, equivalent strength (EST) developing a mechanical parameter (mechanical specific energy) from the oil industry, which is converted only from drilling performance parameters; drillstring rotational torque, bit depth and drillstring rotational per minute. Data processing was applied to the data taken from the advanced drillship Chikyu during her challenging scientific expeditions under International Ocean Discovery Program (IODP) and exploratory drilling in the Indian National Gas Hydrate Program (NGHP). The depth profiles of the EST in these expeditions indicate that the rock strength does not simply increase with depth and that EST changes according to strata and structure. For example, EST significantly increases at the hydrate-bearing zones, suggesting EST can be an indicator of cemented structure, such as the hydrate-bearing zone.

In order to correlate EST with conventional strength unit, drilling experiments using a high-speed friction tester were performed in the laboratory. Stainless-steel drill bits fitted to the apparatus were manufactured, and a standard rock (Indian sandstone) was drilled at a rotational speed of 0.001 to 0.2 rpm under normal stress of 0.2 to 1.0 kN (equivalent to 1.6 to 8.1 MPa). Drilling torque and penetration speed at each condition were measured. The mean EST calculated, based on the recorded drilling data, was 90.5 MPa, which is comparable to the uniaxial rock strength of the standard rock, 106.8 MPa. No significant influence of rotation speed on EST was found in the experiments. The drilling experiments were conducted on several types of sediments similar to the sandstone, and it was confirmed that EST showed a good correlation with the strength of each specimen.

Paper M. Improved Permeability Estimation: From Static to Dynamic to Understand Productivity Better

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Permeability is a measure of a rock's ability to allow fluid flow. Fluid flow is not only related to the pore-throat size and distribution, which is absolute or intrinsic permeability; but also, it manifests the flow ability of different fluids to move through the pore space, which is effective permeability. When to evaluate productivity during exploration stage, the general practice is often focused on the intrinsic permeability estimation from LWD or wireline logs, or core analysis, but effective permeability and its interrelationship to intrinsic permeability has been overlooked; the result therefore can lead to the large error for production prediction in the early stage of life cycle, especially in complex reservoir systems, such as heterogeneity and low-permeability formations etc., consequently impact the decision-making process of completion schemes, and development plans.

Hydrocarbon exploration offshore South China Sea successfully explored Lufeng A and C structures in Lufeng Sag in the Pearl River Mouth Basin (PRMB). This exploration demonstrates the breakthrough in the exploration of deep area of Paleogene system; it further proves the huge exploration potential of the Paleogene system in the PRMB. Under the joint control of tectonic-depositional processes in the deep formations of Lufeng sag from a seismic interpretation example, many fault intersection patterns, unconformity and deformations are the main characteristics of the reservoir architecture, and the reservoir size varies from small to large across, and reservoir heterogeneity is predisposed to be strong. To optimize the operating and capital expenditure, joint development with existing platforms is the main strategy for the new blocks, therefore the productivity evaluation during the exploration phase needs more accuracy, so that the well capacity could be mapped to the suitable platform for later development; this requirement brings permeability as one of key controlling factors of productivity to the fore.

This paper delivers a new workflow of permeability evaluation, that is to integrate resistivity ratio clusters, logging facies and lithofacies classification based on openhole logs and core data to identify rock types and build an intrinsic permeability model; then use wireline formation tester (WFT) mobility, WFT flowing mobility and WFT pressure-transient analysis (PTA) to quantify effective permeability, and establish a relationship between intrinsic permeability and effective permeability; Lastly, it delivers improved reservoir quality index (RQI) and productivity index (PI) for the formation evaluation in an exploration well. The result was used not only to optimize the drillstem test, but also it showed the solid match with DST, and provided the general practice in this field for later well correlations.

Paper N. The Investigation of Sonic Log Response in Gas Dissolved in Water Reservoir—Case Study of Nakajo

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The onshore Nakajo oil and gas field in Niigata Prefecture is composed of three different types of hydrocarbon accumulations: nonassociated natural gas, natural gas dissolved in water (GDW), and black oil. The natural GDW is produced together with formation water as gas in solution (GIS) under in-situ condition. While the formation water is lifting to surface, the natural gas is separated from the water. With this reason, well-log response from GIS sandstone was believed to be almost the same as normal sandstone that does not contain any hydrocarbon. In the recent infill well drilling campaign for GDW reservoir, the full suite of wireline logging was carried out. With a success of good quality data acquisition, an

advanced sonic and borehole image analysis was conducted. As a result, gas-effect-like sonic log response, such as significant P-wave slowness slowing down and unchanged S-wave, was newly observed in GIS sandstone formation, while other logs such as neutron and density did not show any hydrocarbon response. In addition, the sonic velocity radial-profiling analysis result indicated slow P-wave formation property radially continuing from the near wellbore into the formation. Based on these observations and following desktop study, we reached the conclusion that a gas-water two-phase fluid model is a reasonable assumption rather than a single-phase fluid of GIS formation. These new findings on sonic log response in the GDW reservoir will introduce us to the further rock physical study in Nakajo oil and gas field.

Paper O. New Generation of Pulsed-Neutron Multidetector Comparison in a Challenging Multistack Clastic Reservoirs: A Case Study in a Brownfield in Malaysia

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Running pulsed-neutron logs in Malaysia has previously been plagued by high uncertainties, especially in brown ields with complex multistacked clastic reservoirs. Together with a wide range of porosities and permeabilities, the acquired logs quite often yield inconclusive results. In addition, the relatively fresh aquifer water (where salinity varies from 10,000 to 40,000 ppm) makes reservoir fluid typing and distinguishing between oil and water even more challenging. Again, the inconsistencies and uncertainties of the results tends to leave more questions than answers. Confidence in using pulsed-neutron logging, especially to validate fluid contacts for updating static and dynamic reservoir models decreased to very low levels within the study teams.

The Petrophysics team took the initiative to conduct a three-tool log-off in one of their wells with the objective of making a detailed comparison of three pulsed-neutron tools available in Malaysia's market today. The main criteria selected for comparisons were (1) consistency of the data, and (2) repeatability and statistical variation. With recent advancement in pulsed-neutron (multidetector) tool technology, newer tools are being equipped with more efficient scintillation crystals, improving the repeatability of the measurements as well as the number of gamma-ray (GR) count rates associated with the neutron interactions. In addition, the newer tools have now up to five detectors per tool, with the farthest detector from the source supposedly being able to "see" deeper into the formation, albeit at a lower resolution. With these new features in mind, the log-off was conducted in a single well with a relatively simple completion string (single tubing, single casing), logged during shut-in conditions only, and the logs were acquired directly one after the other (back to back) to avoid bias towards any particular tool. Both sigma and spectroscopy measurements were acquired to compare the capabilities of each tool. Due to the relatively fresh water salinity, the carbon-oxygen ratio from the spectroscopy measurements was used to identify the remaining oil located in the reservoirs, while the sigma measurements determine the gas-oil or gas-water contact, if present.

This paper illustrates the steps taken by PCSB to compare the raw data and interpreted results from the three pulsed-neutron tools. A comparison from all the tools is discussed at length, and consequently compared to the current understanding of the reservoir assessment. The points from these comparisons show why one of the tools is more favorable than the others.

Paper P. Porosity-Independent Methodology for Permeability Prediction Based on Microresistivity Images and Laterolog Resistivities: Case History From Kuwait

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Existing methodologies for deriving permeability from microresistivity images rely on porosity transforms. However, because the relationship between porosity and permeability in carbonates is not well defined, it is necessary to identify alternative methodologies to help improve permeability estimates in carbonates.

This paper discusses a new workflow using downhole logging-while-drilling (LWD) tools that can provide a porosity-independent estimation methodology for permeability indicator based on microresistivity images. In a microresistivity image, voids of rock encountered during drilling in a water-based mud (WBM) system are filled with conductive fluid and displayed as darker-conductive pixels. The introduced method identifies and determines a number of all conductive pixels from a histogram based on microresistivity values of a high-resolution image. This method calculates a cutoff value for the above histogram using an invasion indicator derived from omnidirectional laterolog resistivity measurements of mud filtrate. A conductive-pixels ratio is then calculated from a combination of the cutoff value and the histogram. The method also normalizes the continuous ratio to formation-tester measured fluid mobility values and provides a qualitative permeability indicator.

This method compares other sources of log-derived permeability values, such as values from acoustic Stoneley waves and nuclear magnetic resonance (NMR) data of the same or offset wells, to the permeability indicator to fine-tune the method. It also includes partitioning of a horizontal section based on the derived permeability profiles and petrophysical attributes because the determination of lateral permeability variations is important to optimize the stimulation and completion design. Additional investigations are desirable to better understand the applicability of this method with the integration of existing field knowledge, production data, and offset well data.

Paper Q. Artificial Neural Networks Application for the Determination of Water Saturation and Porosity in Shaly Sand Reservoirs

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Evaluation of petrophysical parameters, such as porosity and water saturation, in shaly sand reservoirs is a challenging task in comparison to clean sand reservoirs. Logging-derived porosity in shaly sands requires shale correction. Archie's formula cannot be used in shaly sands for the determination of water saturation, therefore many water saturation models were proposed to get

accurate water saturation of shaly sand reservoirs. In this paper, three water saturation models were used; two empirical models (Simandoux and total shale) and one theoretical model (effective medium model). Shale-corrected density log was used in all models. The use of a computer-generated algorithm, fuzzy-log neural network, is of increasing interest in the petroleum industry.

This paper presents artificial neural network (ANN) as an effective tool for determining porosity and water saturation in shaly sand reservoirs using well-logging data. The ANN technique uses the prevailing unknown nonlinear relationship in data between input logging data and output petrophysical parameters. Results of this work showed that ANN can supplement or replce the existing conventional techniques to determine porosity and water saturation using empirical or theoretical water saturation models. Two neural networks were presented to determine porosity and water saturation using GR, resistivity and density logging data and adapted cut off for porosity and water saturation. Water saturation and porosity were determined using conventional techniques and neural network approach for two wells in a shaly sand reservoir. The neural network approach was trained for porosity and water saturation using the available well logging data. The predicted porosity and water saturation values have shown excellent matching with the core data in the two wells in comparison to the porosity and water saturation derived from the conventional techniques.

This work has clearly shown that the developed neural network (ANN) can accurately determine porosity and water saturation when compared to the existing conventional techniques, especially when experimental core values of shaly sand reservoirs are used. The developed correlation works well in predicting the mode of shale effects on logging data used as inputs and during output analysis.

Paper R. Using Machine Learning for Efficient Electrofacies Classification of Carbonate Reservoirs in a Giant Southern Iraqi Oil Field

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Understanding electrofacies properties and identifying their major categories is a key step in reservoir characterization. Describing the accurate electrofacies is vital in constructing representative reservoir models, which are need to define the optimum development plans and strategies. Electrofacies classification is commonly conducted manually or with the use of some graphing approaches; recently different machine-learning techniques and algorithms have been adopted to categorize electrofacies.

In this paper, two machine-learning techniques were implemented to identify electrofacies in a well from a giant carbonate reservoir in southern Iraq. The given data included well-log records and special core analysis data. The machine-learning algorithms were implemented in R software, which is an efficient statistical and programing tool. The two adopted techniques are kernel support vector machine (KSVM), and probabilistic neural networks (PNN) which are considered to be supervised-learning algorithms. These supervised-learning techniques were implemented in this paper as they are nonlinear classifiers which is imperative attribute due to the non-linearity of the electrofacies properties and the geological reservoir control. KSVM and the PNN approaches distinguished the distinct electrofacies based on maximizing the margin around the separating hyper plane and the decision function is fully quantified by a subset of the associate vectors. The efficient classification of electrofacies helps to anticipate the optimum spatial distribution of reservoir parameters and thereby modeling process will be improved.

The results of this research show that reservoir electrofacies can be predicted through the use of the supervised-learning techniques when well-log records and core data are available. The two adopted classification algorithms were analyzed and compared based on confusion table, transition probability matrix and total percent correct (TCP) of the identified electrofacies, which reveal the accuracy of the classification. KSVM was observed to be the optimum approach and therefore it can be used to improve reservoir characterization by enhancing electrofacies classification. The application of machine-learning techniques enhanced the accuracy and reduced the time spent in electrofacies classification.

Paper S. Application of FPWD to the Reservoir Description and Completion Optimization in Highly Deviated Wells in South China Sea

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[1]CNOOC Zhanjiang
[2]Schlumberger

With the development of directional drilling technology, more and more appraisal and development wells in the South China Sea are drilled with a high inclination, which can reduce the rig mobilization cost, maximize the trajectory footprint in reservoir and improve the project CAPEX. At the same time, the formation pressure measurement plays an important role in the reservoir description and completion design. Because the formation pressure acquisition requires stationary time, the conventional cable-conveyed technology cannot fully meet the operational requirement. Therefore formation pressure-while-drilling (FPWD) technology has been developed to fit the needs in such high-inclination wells.

FPWD technology essentially takes probe, setting piston, precise pressure gauge built into a collar which can be compatible with all other logging-while-drilling (LWD) tools. When taking the pressure measurement, the setting piston can push the entire tool to contact the borehole wall and create a fully sealing volume between tool and formation pore. Then the probe draws the fluid to create the pressure re-equilibrium, which will be recorded by the pressure gauge. Formation pressure is then derived from the pressure recording there. In order to minimize the stationary time and reduce risk, the semiartificial-intelligence approach within tool is also developed to automatically choose acquisition parameters within preset time limit. With the enabling of formation pressure measurement from FPWD technology, various applications have been tried in high-inclination appraisal and development wells in thee South China Sea. These include reservoir energy depletion profile determination, fault-sealing determination and artesian gas injection optimization, etc. FPWD provides the critical information for reservoir description and production enhancement in the South China Sea.

Paper T. First Hexa-Combo While-Drilling Run Unlocks New Logging and Completion Design Era: Case Study From Gas Team of Kuwait

Anar Abdulkarim[1], Ahmet Aki[1], Shahrin Sainuddin[1], Mejbel Saad Al-Azmi[2], Fahad Barrak Al-Otaibi[2], and Girija Kumar Joshi[2]

[1]Halliburton
[2]Kuwait Oil Company

For directional wells in a Jurassic formation, the 6-in. production sections that are normally drilled in the Marrat reservoir require several separate wireline logging (WL) runs and associated borehole conditioning trips for complete petrophysical interpretation and completions design.

As planned well inclinations increase to maximize sweep, the need for deploying WL tools via drillpipe poses significant challenges due to the high risk of losing the bottomhole assembly (BHA) in the hole due to differential sticking. Over time, logging-while-drilling (LWD) tools became preferable for the gas team, where the tools are either run with the actual drilling BHA or on a dedicated wiper trip after the section has been drilled to total depth (TD). Using LWD tools in this application also reduces well delivery times and costs. A comprehensive logging solution was required to drill the 6-in. reservoir section of a study well. The complex LWD string consisting of gamma ray, resistivity, neutron porosity, azimuthal density, azimuthal sonic, and nuclear magnetic resonance (NMR) tools was deployed on a motorized rotary steerable system (MRSS) BHA. In addition, a prototype high-resolution acoustic imaging and caliper tool, designed to be run in both water and oil-based mud (OBM), was also use in the same BHA. The acquired logging data were used for enhanced formation evaluation. Fracture and borehole breakout interpretation from image data played the key role in successful completion design. This ultimately led to Kuwait's first successful "Hexa Combo" LWD drilling run and the world's first LWD imaging tool run in OBM in this hole size with 13.3 lbm/gal OBM with a maximum downhole temperature of 275°F.

Paper U. Arresting the Production Decline and Increasing the Ultimate Recovery of a Mature Oilfield in Offshore South China Sea

Gao Xiao Fei[1], Shen Xu, Dai Ling[1], Shim Yen Han[2], Wang Chao[2], Gao Bei[2], and Ding Sai Jun[2]
[1]CNOOC Shenzhen
[2]Schlumberger

A brownfield adjustment project was initiated by theee China National Offshore Oil Corporation (CNOOC) in 2014 to improve production and further increase reserves recovery from Huizhou 25-8 oil field and Xijiang 24-3 oil field in the South China Sea, also known as the Xijiang 24-1 District joint development project.

New development wellswere drilled targeting at the remaining thin (< 5 m) oil column or pursuing highly heterogeneous sand bodies. The redevelopment and exploitation of these targets present operational challenges with increasing complexity. Not only the horizontal well needs to be optimally placed within complex target zone, the lateral also needs to be placed as close as possible to the reservoir top to keep it away from the unknown current fluid contact. Real-time evaluation of the horizontal section is needed to steer the well following better sand quality when formation properties change laterally. Considering all the challenges presented, the team must ensure each well can achieve the target productivity index to attain technical and economic success.

Multiple cases are discussed in the paper based on 34 wells drilled since the launch of this joint development project. Several key outcomes that have been observed will be highlighted, including

(1) Selection of logging tools to address well-specific challenges.
(2) Using real-time bed boundary detection technique to optimize the standoff between horizontal section and top of formation.
(3) Real-time evaluation to appraise formation heterogeneity.
(4) Evaluation of productivity index while drilling to optimize the horizontal section length.

Based on the well performance results obtained from this redevelopment project, the implementation of the best practices in operations is the key enabler to effectively place the trajectory in the best place to drain the remaining hydrocarbon that lead to maximizing the late-life value of a mature oilfield.

Paper V. Ultra-Deep High-Definition Reservoir Mapping-While-Drilling Measurement to Optimize Landing Operation: A Case Study From Offshore China

Wei Li[1], Jianbo Chen[1], Baoqiang Jin[1], Junshou Zhao[1], Meng Deng[1], Fei Wang[2], Shim Yan Han[2], Chao Wang[2], Shuzhong Li[1], and Xin Zhou[2]
[1]CNOOC Tianjin
[2]Schlumberger

Precise landing operations are critical for horizontal well placement. Conventionally, operators rely on the real-time logging-while-drilling (LWD), which is used to confirm the markers above the target formation according to correlation with offset wells, combined with surface seismic data to predict the depth of target zone, and to optimize the trajectory plan and ensure accurate landing. However, little information from offset wells, no clear markers above target formation, poor quality seismic data, uncertainty of lateral sand body distribution and unstable disturbance layers above target zone etc. further increase the risk of landing operation.

This paper features the successful landing using innovative LWD technology. This innovative solution reduces uncertainties of structural depth and formation properties by forecasting the formation boundaries using ultradeep resistivity measurement and upgraded inversion methods. The execution of the well placement will be detailed through the description of the case encountered. The operator has observed outstanding results from the application of the innovative technology during the landing operation:

- Reduction in the need for pilot wells.
- Improve drilling efficiency by proper landing, avoiding unnecessary adjustments and sidetracks.
- Real-time detection of the target up to 20 m away during landing.
- Delineation of >10-m thick sand bodies up to 10 m above the sand.

The successful implementation of the ultradeep high-definition reservoir mapping-while-drilling measurements leads to improve drilling efficiency, reduced costs and mitigates drilling risk for landing operations. In addition, the ultradeep mapping capability of the service can help delineate the reservoir profile with more accurate models and help to understand the complex subsurface conditions.

SPWLA Young Professionals Newsletter

the bridge

Reminiscences of the Logging Profession—*I Did It My Way*

NOVEMBER 2019

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At my advanced age, I frequently listen to Frank Sinatra's "My Way". The lyrics were written by Paul Anka to help Frank celebrate his retirement. The song was such a big hit that Frank Sinatra cancelled his retirement and went on singing and touring for several years thereafter. My Own Way through my career was to interact with as many smart people as I could find, and to learn from them. Within SPWLA, I did find very smart people. Some were dysfunctional, some were nice, some were passive-aggressive, some were not so good-looking; but they were all very smart. I could not possibly recount my interactions with all of them, but I will cover those that stuck in my memory. If you do not find your name in my article, do not be upset, you were probably too wise to make it into my "unusual characters" roster.

The first time I met Barbara Anderson, she was working closely with Stan Gianzero. They were trying to model resistivity tools in a square borehole. I was too puzzled to even raise an eyebrow. A square borehole? What were they thinking of? Several years later Nigel Prior explained to me: "What you did not know was that, adjacent to Stan's office, there was a mechanical engineer wizard busy designing a square bit to drill square boreholes." That was in the 1970s in Ridgefield. The square-borehole model did lead to the successful design of the Spherically Focused Log. A few months later, I witnessed another interesting event during a redeye flight to Paris. I was sleeping blissfully. Next to me, Stan Gianzero suffered from insomnia. He used the idle time to invent microelectrical imaging. He would wake me up during the flight to explain to me the intricacies of microfocused electrodes.

Our department manager, Jean Suau had a postal scale prominent on his desk. He explained to me that he used the scale to assess the work of his employees. He weighed their monthly reports; the heavier they weighed the less work was probably achieved. I was particularly impressed by Darwin Ellis, down the hall from me, busy inventing the photoelectric log.

Christian Clavier urging Jean-Claude Minne to Disco (1973).

The department manager who influenced me the most during my early career was Christian Clavier. He had novel ideas on every topic and he pursued them with enthusiasm and near-obsession. From dielectric to pulsed neutrons to petrophysical models, nothing escaped his perspicacity and his sagacity. His creative mind stopped at nothing. He formed a triumvirate with Coates and Dumanoir and pioneered the Dual-Water model. Like every eminent petrophysicist of that era, he went to war with competing petrophysicists and their competing models. There were jousts between Clavier and Waxman and Smits, between Poupon and Simandoux, between Turk Timur and Paul Worthington. Annual Symposia were much less restrained and polite in those days. Courtesy and civility were left at the door. I found myself in the odd position of brokering peace between the different factions. On the sidelines, other moderate petrophysicists were also trying to see clear

As a field Engineer in North Sumatra I adopted a miniature monkey, a rascal named Toto.

through the dust. Some were wise and calm like E.C. Thomas, and Jean Dumanoir; others were enjoying the fray, like Richard Bateman. Simandoux escaped from Petrophysics wars to the French Petroleum Institute where he received a big promotion and sat behind a very big desk. Several years later, I happened to walk in his big office. I congratulated him on his famous "Simandoux equation". He fell off his chair. He could not imagine that people actually used it. Little did he know.

The next big phase of my career was with a small logging company founded by a maverick from Kansas named Marvin Gearhart. I saw up close what a true entrepreneur looked like. He was a wonderful man who cared for his people but with a strong taste for risky enterprises. No venture could scare him. He manufactured explosives and created digital logging. He built a hi-tech neutron generator facility in Fort Worth, and funded a research center in Austin for advanced logging technology. Marvin was only intimidated when my supervisor Stan Gianzero threw triple integral equations at him. That is when he left the room and went to fly his Mitsubishi. It is during one of his Mitsubishi trips that I saw the true entrepreneur at work. We landed in Tulsa at the Amoco Research Center. We had a burger lunch with Al Jaggler. On a paper napkin, Marvin and Al drew a rotary coring tool. All sidewall coring up to that point was done with explosives. The rotary sidewall-coring tool would revolutionize the industry. Barely a few months after our Tulsa trip, at the Annual Symposium, Marvin had his tool on display, functioning, and cutting nice smooth core plugs from a sandstone block. Marvin's "Elon Musk" gusto was great for innovative technology, but not so great for finances. My colleague Edgar Ortiz was looking after the business side of the company with some success; but then, in the late 1980s a double whammy of falling oil prices and an attempted hostile takeover threw Gearhart Industries in disarray. Thankfully, a white knight named Halliburton came to the rescue and saved Gearhart from bankruptcy.

On CBS "60 Minutes". The CEO of Saudi Aramco explains Geosteering to Leslie Stahl.

As an engineering student at the Ecole Polytechnique of Paris, I donned a military uniform. My girth has somewhat expanded since.

With Halliburton, I reentered the world of the big corporation. My new supervisor, Harry Smith, was an expert in nuclear physics who, curiously enough, was also great at managing people. This combination is unheard of. There must have been some accident in the time-space continuum. Harry and his colleagues had invented a new form of neutron thermal decay log that revolutionized casedhole logging. It is because of Harry's continual pursuit of excellence that I was forced into petrophysics. While normal petrophysicists get into petrophysics for love of the rock, I went into petrophysics in order to justify to my supervisor

I have always enjoyed training and mentoring. Here I am assisting my friend Billy Hendricks with a training class for Sonangol Petrophysicists.

why a logging tool responds as it does. Why do laterologs read stubbornly higher than induction? I had to study anisotropy and laminated reservoirs. Why do LWD tools read lower than induction? It was because of resistivity dispersion in sedimentary formations. Magnetic resonance was emerging as an exciting technology, thanks to Turk Timur and to Numar. Others followed. I wanted to grasp all the possibilities and the limitations of magnetic resonance. I had to get more intimately involved with the science of the rock and of the fluids. My friend George Coates had joined Numar. He single-handedly saved magnetic resonance logging by weaning it from permeability and linking it to bound water. I did work closely with Harold Vinegar and Ridvan Akkurt, the other giants of magnetic resonance. I told you I gravitated around smart petrophysicists, trying to suck their brains dry.

My life took an interesting twist at the turn of the millennium. Horizontal wells had become the rage simply because with a single horizontal well you can extract 10 times more oil from the ground than with a vertical well. Two gentlemen, who never met, changed then the course of my career. Volker Krueger, inventor of the rotary steerable, dedicated his fine German engineering skills to the development of advanced drilling machines, well adapted to horizontal wells. Almost simultaneously, Michael Bittar, a PhD from the University of Houston, invented an electromagnetic array with tilted coils that helped steer the horizontal wells to the sweet spot of the reservoir. Well placement became the frenzy. I threw myself into it, forgetting about petrophysics for a few years. I felt that I had betrayed my roots.

The SPE, who is not particularly partisan to pure petrophysics noticed my work. They offered me the much-coveted Distinguished Lecturer spot. I traveled around the world spreading the doctrine of accurate well placement. In my slide presentations, I interlaced with the science some funny videos to illustrate the challenge of steering within a narrow path. I recall showing up in the beautiful city of Tomsk, in Eastern Siberia, in the cold of winter, to a standing-room only audience. Even the local TV was there with simultaneous translators. Before I could even start my presentation someone from the audience asked me: ”Are you going to show your funny videos?” How could they have known about my funny videos? They had conversed via internet with their colleagues from Moscow and from Western Siberia, whom I had visited earlier that month. At least part of my message had been shared between Western Siberia and Eastern Siberia.

Right after my worldwide tour as SPE Distinguished Lecturer, I was elected President of SPWLA. I was humbled and honored. I had returned to my roots. Unconventionals were in vogue. Petrophysics had regained its status of noble science because if you wanted to make any sense of source rocks, you had to be a genius. I found out much to my surprise that the Passey equation had actually been invented by my friend Quinn Passey. I was thinking to myself: ”Surely the real Equation Man must be much older, much more stern than the boyish looking Quinn?” I was wrong. The boyish look was just a decoy.

I recently joined a large independent operating company. I wanted to experience life from the other side. The side that orders and pays for, and uses the data. I had regarded petrophysicists in the operating companies as semi-gods who knew everything. I was going to be one of them. Finally, I will have access to The Truth. Here again I landed on a smart supervisor. I should not reveal his name because people would think that I am sucking up to him. However, by the time this goes to print, I would have moved on. He will no longer be my supervisor. I can reveal his name with impunity. My latest supervisor is Kent

I have also always enjoyed the hard-working sessions at UT Consortium over Austin’s Townlake.

Sometimes I had to seek wisdom from shrines from the Orient (India in this case).

Newsham. He reminds me in so many ways of Christian Clavier, minus the French accent. He is intense, creative knowledgeable and obsessed with petrophysics. Like Christian Clavier before him, he comes in my office unannounced, aims for the board, and starts scribbling new ideas and new concepts. My board looks like a Basquiat masterpiece. He recently formed a triumvirate including Joe Comisky and myself. We authored a three-part tutorial on mudstones, published in *Petrophysics* under the auspices of Carlos Torres-Verdin. Kent will challenge any petrophysical model that does not agree with his own. He is ready to go to battle to prove it. Like Christian Clavier, he was born under the sign of Scorpio. Sometimes I think to myself: I have come full circle in 50 years, from my first mentor to my latest mentor who are so much alike. Will there be more adventures to come in the life of this petrophysicist? Possibly a fifth career, consulting, mentoring and tutoring. I will do it My Way.

Other times I wore a suite to dispense wisdom to Petroleum Engineers (near Nanjing, China).

SPWLA Networking Happy Hour in October 2019

Several SPWLA members from the greater Houston Metro area gathered recently for the SPWLA October networking event. A beach-style patio and bar conveniently located was the perfect spot to network in a relaxed atmosphere. SPWLA members attending the October happy hour included colleagues from academia, operating, service and consulting companies. There was a diverse crowd that ranged from new members still in undergraduate school to some recently retired professionals. The exposure of new members to experienced or retired professionals offered great opportunity. Members attending also had the opportunity to interact with several SPWLA current and past international and local officers, including SPWLA International President 2019–2020 Jesus Salazar, and couple of SPWLA Houston Chapter Vice Presidents Jacob Anderson and Javier Miranda (Westside and Downtown sections respectively).

Recent and upcoming technical and social activities organized by the Houston Chapter, including the Houston Chapter software show in December and the last networking event for 2019 that will take place immediately after the software show on December 4, were also discussed. As usual, a group of students from the SPWLA University of Houston Student chapter, including their president Charles Adams, also joined us.

These bimonthly events, which are popular among SPWLA's Houston area members and visitors, are rotated among different locations across the Houston metro area. You are encouraged to share recommendations if you are interested in joining us in a place near you, especially if you and your team and colleagues will attend. So far, we have rotated locations among the energy corridor and uptown, midtown, and downtown. Sponsorship opportunities are currently available for these events!

SPWLA members and petrophysics enthusiasts gathered recently for the fourth SPWLA networking event in 2019. SPWLA International President 2019–2020 Jesus Salazar, and couple of SPWLA Houston Chapter Vice Presidents, Jacob Anderson and Javier Miranda, Westside and Downtown sections, respectively, were also in attendance.

SPWLA Networking Happy Hour in October 2019

Tikila's, a beach-style bar conveniently located with a relaxed atmosphere was the perfect place to enjoy the most recent SPWLA's networking event in October 2019.

SPWLA members and petrophysics enthusiasts during the most recent networking event enjoying a MLB postseason atmosphere and rooting for the Houston Astros, the local team, October 2019.

The most recent happy hour was well attended by more than 30 SPWLA professional and student members coming from different companies and locations in the great Houston Metro area.

SPWLA members having a great evening full of laugh and conversation in a very diverse environment with people representing academia, operating, service and consulting companies.

SPWLA Networking Happy Hour in October 2019

Several people from industry and academia (University of Houston students) attended SPWLA's Happy Hour in October 2019.

SPWLA International President 2019–2020, Jesus Salazar (first from left to right) with SPWLA members from the Houston Metro area.

Don't Miss Our Next Event!

Join us for our next event in December 2019. Our fifth and last SPWLA Networking Happy Hour in 2019 will be held on December 4, 5:00–8:00 p.m., at a location to be announced, as usual, it will be a location accessible for anyone in the greater Houston area. It will be held **right after the Houston Chapter software show**. We are listening suggestions from our members and will select a venue several people can attend. You are also welcome to recommend new locations close to you, especially if you and your colleagues will attend!

The entire SPWLA community is invited, no need to RSVP, come at your own leisure, no payment required. Come and mingle with fellow petrophysics enthusiasts. Recent events have been well attended by geoscientists, engineers and managers!

Everybody is welcome!

When: Wednesday, December 4, 2019, 5–8 p.m.

Where: TBD, Houston, Texas, USA

Send us your articles, stories, fun moments, photos, etc. to be published in The Bridge.

Contact us: SPWLAYP@SPWLA.ORG

We encourage you to contact us with any suggestions for improving our group and/or if interested in participating in our activities.

Society of Petrophysicists and Well Log Analysts

Petrophysical Data-Driven Analytics

The SPWLA Petrophysical Data-Driven Analytics (PDDA), Special Interest Group is excited to announce its first scholarship!

The scholarship is open to graduate students who conduct research in the field of petrophysics and data science. The $1,000 scholarship will be awarded to one qualifying student. In order to be eligible for the scholarship, student applicants must meet the following requirements:

Requirements:

- Have a minimum GPA of 3.0 on a 4.0 scale
- Submit a copy of your transcript (official or unofficial) and a resume/CV
- Write a short essay (< 800 words) on why the applicant is interested in the field of applied data science to petrophysics.
- **Include at least one letter** of recommendation from a professor, or a supervisor of summer or co-op work experience, or a supervisor of research work.

Submission Deadline: December 1, 2019.

The winner of the scholarship will be announced by December 31, 2019.

Please submit all the required materials to ppda_sig@spwla.org

SPWLA Call for 2020 BOD Election Expressions of Interest (EOI)

From the Past President and Chairman of the Nominating Committee

Fellow SPWLA Members,

This is an open call for Expression of Interest (EOI) in the SPWLA 2020 Board of Directors election. It is expected that anyone with interest in serving on the Board will make their intentions known during this open call period. If you plan to send your EOI to serve on the 2020–2021/2022 Board of Directors please, do so on or **before Sunday November 10, 2019.** If you know someone who would be a great candidate, please encourage him/her to express his/her interest.

The positions that are open for election this year:

- President-Elect
- Vice President Technology
- Vice President Education (2-year term)
- Vice President Publications (2-year term)
- Regional Director North America Position (2-year term)
- Regional Director Middle East/Africa (2-year term)
- Regional Director Latin America (2-year term)

The duties of each position are provided in the **DIRECTORS MANUAL** to support your potential decision to volunteer on the International Board of Directors. Please also note that SPWLA members have recently voted to make changes to the Bylaws and Articles of Incorporation, which added qualification requirements for candidates and positions. Following are some highlights of the requirements.

1. All qualified candidates on the slate must have been an SPWLA member in good standing for at least three years and abide by the SPWLA Code of Ethics.
2. Nominees for VP Technology shall have previous experience on a technical committee of SPWLA or sister organizations and have authored a minimum of two papers published in international conferences. Nominees for VP Education shall be knowledgeable and active on social media channels.
3. Nominees for VP Publication shall have previous experience as technical editor for a peer-reviewed journal and have authored a minimum of two papers published in peer-reviewed journals.
4. Nominees for VP IT (note: this position is not open this year) shall have some experience on web standards and tools to regularly update and modernize the SPWLA website.
5. The VP Technology will not be permitted to publish papers as lead author or be the presenting coauthor at the SPWLA Annual Symposium during his/her term to avoid conflicts of interest. However, the VP of Technology may still be a coauthor on up to two papers presented at the symposium.
6. The VP Publications will not be permitted to publish papers in *Petrophysics* during his/her term to avoid conflicts of interest.
7. A Director shall not serve on the Board for more than five consecutive years unless elected as President-Elect. Please refer to 2019 Bylaw changes, and the updated Bylaws to make sure you are qualified for the positions you are interested.

To express your interest please send an email to zliu@spwla.org with the following information:

1. Full name
2. Email
3. Phone
4. Current city and country of residence
5. Company affiliation
6. Positions you are most interested in filling in the order of your preference (these will be considered but may not be honored).
7. Optional: a brief position statement (<100 words)
8. Optional: Your LinkedIn profile.

Your interest will be evaluated by the Nominating Committee. Please note that **submission of an EOI does not guarantee your inclusion on the proposed ballot**.

Last but not the least, I sincerely appreciate the men and women in the nominating committee for their wisdom, experience, and hard work.

Regards,
Zach Liu
Past President SPWLA and Chairman of the Nominating Committee
zliu@spwla.org

ABERDEEN CHAPTER
(Aberdeen Formation Evaluation Society, AFES)

General News

AFES held its Annual General Meeting on 09 October. Among the review of the recent year's activities, new members were ratified into the Committee. In particular, new subcommittee members Chris Blair (Total), Alex Kaye (LR), and Ali Swan (Student Representative). Also of note is the recent stepping down of Richard 'Quiz Master' Arnold, who has been involved with AFES for almost 20 years. Richard is perhaps most well-known for his much loved AFES Christmas quizzes, in addition to his sustained input and support for AFES. We've enjoyed working with you Richard, so thank you for your help and support.

AFES Committee member update:

Position	Current 2018-2019	Proposed 2019-2020
President	Greg Blower	
Past President	Ed Downer	
DEVEX Representative	Ed Downer	
VP Technology (Lectures)	Stephanie Morris	Chee Kong Chen
Secretary	Michelle Ferris	Kostas Christou
Communications/Media Officer	Jeremy Titjen	
Treasurer	Neil Cardy	
University Liaison Officer	Ebrahim Heydari	
Sponsorship	John Banks	
Student Rep	Sean Little	Alistair Swan
Technical Committee	Richard Arnold – stepping down Craig Lindsay Damien Dennison Chris Blair (Total) Alex Kaye (LR)	

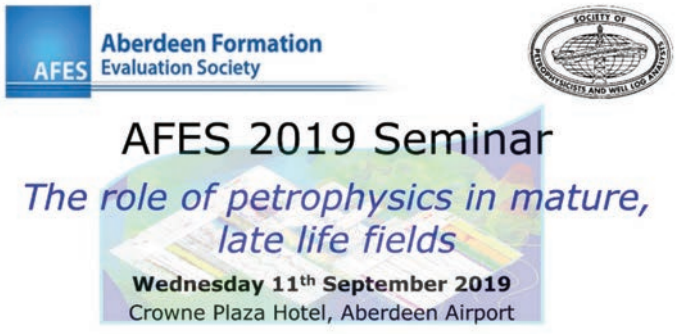
In general, please do communicate with AFES if you have any suggestions or thoughts for evening presentations, or indeed more involved multi speakers seminars – we're always open to ideas!

Recent Events

02 July 2019 – AFES geology field trip / summer social to Stonehaven (~15 miles south of Aberdeen) to the exposed rocks below the high-water line. A beautiful Aberdonian summer's evening was enjoyed by all, followed afterwards by fish and chips at the harbor.

AFES July 2019 field trip. Stephen Morris (VP Seminars) guiding us through the geology at Stonehaven beach, near Aberdeen.

11 September 2019 – Full-day seminar on the "Role of Petrophysics in Mature Late-Life Fields." The day was a success, being hosted at a new venue, The Crowne Plaza Hotel, near Aberdeen Airport. We hosted seven speakers to an engaged, well attended audience. AFES hopes to host another event in Spring 2020 at the same venue.



Speaker	Affiliation	Title
Greg Blower	AFES	Welcome and Opening Address
Jules Reed	LR	Residual Oil Saturation – Can Correctly Controlled Experiments Provide the Answer?
Remke Ellis	TGT	Assessing Suitability of Wells for SWCT
Florent Bringer	SLB	The Value of Spectroscopy for Mature Fields in Cased Hole Environment
Viktoriya Nam	BHGE	PLT and ARH (Array Resistivity Holdup)
Andreas Hofmann	SGS Services	A Novel Technology for Assessing the Mechanical Properties of Drill Cuttings and Upscaling to Reservoir Scale
Remke Ellis	TGT	Remedial Repair and Production Optimization with Through Barrier Diagnostics
Alan Johnson	IPS	The Enduring Presence of Petrophysical Uncertainty
G. Blower/ S. Morris	AFES	Additional Discussion, Closing Remarks, Future Events

AFES September 2019 full-day seminar. AFES President, Greg Blower, presents the "Donald Keir Prize for Petrophysics" to Wei Wei Yong, Aberdeen University.

18 September 2019 – AFES resumed its Wednesday evening talks with a presentation by Guy Wheater (Gaia Garth Technologies) on identifying and mitigating wireline cable sticking,

AFES September 2019 meeting. Stephanie Morrison (VP Technology) hosting speaker Guy Wheater (Gaia Earth Technologies).

09 October 2019 – AFES AGM. This event updated the membership on the year's events, finances, SPWLA relationship, committee member ratification and finances. The evening was finished with a great off-topic talk on submarine adventures in the Bahamas by Peter Cranston (Aberdeen Toastmasters).

23 October 2019 – SPWLA Distinguished Speaker Nishank Saxena (Shell).

Upcoming Events

13 November 2019 – The regular Wednesday evening presentation will be given by Maneesh Pisharat (Schlumberger) on "Characterization of Fluid Composition While Drilling to Aid Well Placement."

28 November 2019 – AFES will host its much loved Christmas pub quiz .

May 2020 – Devex 2020. The 'call for abstracts' flyer for this two-day event is now live.

ABU DHABI CHAPTER

General News

The Chapter encourages all Petrophysicists interested to join and become active members. Get in touch, if you wish to attend our local events, or present at any of our technical events. If you want to be added to our email list, please email us at admin@spwla-abudhabi.com . We are also on LinkedIn- SPWLA Abu Dhabi Local Chapter. We would love to hear from you!

Recent Events

The chapter went quite during the summer break and resumed technical talks event in September.

September 2019 – The chapter hosted a Technical talk at ADNOC HQ Rig theater. Deepak Voleti (ADNOC Onshore) delivered a presentation titled, "How ADNOC Onshore Innovated to Improve the Quality of Reservoir Permeability Predictions Using Machine Learning."

Abu Dhabi Chapter September 2019 meeting. Deepak Voleti (Senior Petrophysicist, BAB) giving his presentation.

AUSTRALIA CHAPTER
(Formation Evaluation Society of Australia, FESAus)

General News

FESAus, the Australian chapter of SPWLA combines the formation evaluation societies from around Australia predominantly FESQ. Technical meetings are held in Perth on the second Tuesday of each month, with webcasts of the presentations available soon after for members from other states to view. Please visit www.fesaus.org for meeting information.

Recent Events

27 August 2019 – An extraordinary monthly technical meeting was conducted by Stephen Adams (The Petrophysicist Limited) and Colin McPhee (Mercat Energy Limited) on "The Impact of Upscaling on Porosity, Permeability and Water Saturation Modeling in Heterogeneous Reservoirs." The talk was well received, with a great deal of discussion and sharing of ideas.

FESAus August 2019 meeting. Presenters Stephen Adams (The Petrophysicist Limited) (left) and Colin McPhee (Mercat Energy Limited).

12 September 2019 – FESAus New Technology Forum. Software Solutions for formation evaluation were represented by Lloyd's Register, Schlumberger and Emerson

- Recent Advances in the IP Geomechanics Suite – Lloyd's Register
- Simulation of Turbidites with Forward Stratigraphic Modelling - Schlumberger
- Big Loop: From Reservoir Engineering to Geology - Emerson
- Casedhole Solutions in the IP Reservoir and Wells Suite – Lloyd's Register
- DELFI Enables Petrotechnical Virtual Data Rooms for the E&P Industry – Schlumberger

08 October 2019 – Vanessa Lim (Principal Petrophysicist, Woodside Energy) gave a presentation titled, "Briggs Color Cubing – A Powerful Visualization Tool for Stratigraphic Correlation and Facies Typing." Vanessa's talk was well received with a great deal of discussion and sharing of ideas.

FESAus October m2019 meeting. Vanessa Lim (Woodside Energy) (left) congratulated by Adrian Manescu, President FESAus.

Upcoming Events

12 November 2019 – Master Class,TBA

10 December 2019 – End of Year Xmas Luncheon – Climate Change

BANGKOK CHAPTER

General News

The Bangkok Chapter of SPWLA holds technical Meetings in Bangkok on the last Thursday of each month. Meetings are fully sponsored for SPWLA Members. Nonmembers can attend free of charge with email registration prior to the meeting. Students are always free of charge.

Please visit https://www.spwla.org/SPWLA/Chapters_SIGs/Chapters/Asia/Bangkok/Bangkok.aspx for meeting information. Email: bangkok.chapter@spwla.org bangkok.chapter@spwla.org.

2019 Chapter Committee Members:

President	Andrew Cox
Technical Coord	Numan Phettongkam
Treasurer	Sirinya Maykho
Web Coordinator	Alex Beviss
Secretary	Ronald Ford
Sponsorship	Ryan Lafferty
Student Liaison	Kruawun Jankaew
Member at Large	Greg Heath

Recent Events

26 September 2019 – Nick Last (Director, Well Test Knowledge International) gave a presentation titled, " Predicting and Mitigating the Risk of Fish during Wireline Perforating Operations."

28 October 2019 – Jennifer Market (Principal Geophysicist, MPC Kinetics) gave a presentation on "Understanding Geomechanics Measurements."

Upcoming Events

28 November 2019 – Graham Melvin (Lloyd's Register) will give a presentation titled, "Lifting the Fog of Confusion Surrounding Deterministic Interpretation."

BOSTON CHAPTER

General News

SPWLA general and Boston-affiliate members are invited to browse our chapter website http://boston.spwla.org for up-to-date information on our mission and events, including event details and registration.

Recent Events

1–2 November 2019 – The Boston Chapter hosted a workshop on the theme of "Porous Media: Structure, Flow, and Dynamics," at Schlumberger-Doll Research Center in Cambridge, Masachusetts, USA. The scientific agenda comprised 50 talks by speakers from Harvard University, China University of Petroleum, MIT, Princeton University, Brown University, Shell, Chevron, Exxon Mobil, Aramco Services Company, and Schlumberger, among others. The program highlighted new developments in high-resolution imaging, digital simulation, and analysis techniques as applied to porous media, with presentations from the perspectives of theory, experimental methods, and field measurements. The Boston chapter organized the workshop in coordination with the NYNE Section of SPE, Schlumberger-Doll Research, Harvard, and China University of Petroleum-Beijing. More information can be found at in the Events section of our chapter website linked below.

Honors

Paul Craddock, Jeff Miles, and Drew Pomerantz (all of Boston), and Rick Lewis (Denver) published their paper on "Thermal Maturity-Adjusted Log Interpretation (TMALI) in Organic Shales" in the October "Best of 2019 SPWLA Annual Symposium" issue of *Petrophysics* journal.

Thai Le, Lin Liang (of Boston), Timon Zimmermann, Smaine Zeroug (Boston), and Denise Heliot (Houston) published their paper on "A Machine Learning Framework for Automating Well-Log Depth Matching" in the October "Best of 2019 SPWLA Annual Symposium" issue of *Petrophysics* journal.

Lin Liang was invited, as the representative of SPWLA, to speak at the 11th UPC international symposium on New Well-Logging Techniques, and gave a Distinguished Speaker talk to the SPWLA East China Chapter.

BRAZIL CHAPTER

General News

Our monthly meeting occurs every third Tuesday of the month, at 4 p.m. in downtown Rio de Janeiro. Anyone wishing to participate or receive information about the chapter can contact our secretary, Andre Bertolini (abertolini@slb.com). We also post chapter updates at our Facebook page (fb.me/SPWLABrazil) and our LinkedIn page – check us out!

Recent Events

13 August 2019 – Dr. Claudio Rabe (Senior Geomechanics Specialist, Baker Hughes) presented a talk entitled, "Petrophysical Analysis for Unconventional Reservoirs."

17 September 2019 – Dr. Anish Kumar (Principal Geology Domain Champion, Schlumberger) discussed the topic "Identifying Geological Deformation Using High-Resolution Borehole Images: Shale and Deformation Band Characterization."

Brazil Chapter September 2019 meeting. Dr. Anish Kumar (Schlumberger) (left) and Lenita Fioriti (Petrobras, SPWLA Brazil President) (right).

CHINA UNIVERSITY OF PETROLEUM (BEIJING) STUDENT CHAPTER

General News

The chapter held a meeting in August to discuss the affairs in the past year and in the future. In September, 22 new members were admitted to the chapter, each branch has four to six new members.

CUPB Student Chapter. Some of the new members of our chapter in 2019.

Recent Events

15 August 2019 – Jiang Jia, the former leader of SPWLA Student Branch of CUPB introduced his major accomplishments over the past several years, such as holding workshops, holding SPWLA Student Paper Competition Contest and so on. He assisted in the transition in leadership to help the new leaders begin as quickly as possible.

15 September 2019 – A ceremony was held to welcome new members. In the ceremony, the student chapter's purposes and objectives were presented.

Upcoming Events

We intend to invite SPWLA Distinguished Speakers to give presentations and to prepare for the the SPWLA Student Paper Competition.

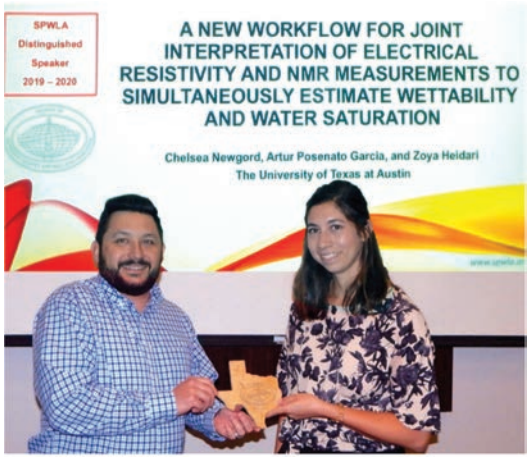
DALLAS CHAPTER

Recent Events

September 2019 – The Dallas chapter continued its tradition of welcoming a graduate student as speaker for its September meeting. Son T. Dang, a PhD candidate at the Mewbourne School of Petroleum and Geological Engineering, University of Oklahoma, presented his project titled "Effects of Temperature and Gas Pressurization on the Interpretation of Nuclear Magnetic Resonance (NMR) Hydrocarbon Measurements in Organic Rich Shales." The presentation stressed the importance for the awareness of missing data within the NMR relaxation sequence for fluids with higher viscosity that would result in an underestimation of movable hydrocarbons using routine core analysis. This is especially true for fluid-rich source rocks. Monitoring real-time recovery of Huff-n-Puff EOR in shales using an NMR experimental set-up was also presented.

Dallas Chapter September 2019 meeting. Son T. Dang, a PhD candidate at University of Oklahoma, was the speaker.

October 2019 – Chelsea Newgord, a Petroleum Engineering graduate student at The University of Texas at Austin, and a twice-selected SPWLA Distinguished Speaker, presented her paper titled "A New Workflow for Joint Interpretation of Electrical Resistivity and NMR Measurements to Simultaneously Estimate Wettability and Water Saturation." The primary focus of her talk was the development of a technique to estimate rock fluid wettability using resistivity and NMR measurements. Using these data obtained using core samples of Berea sandstone and Texas Cream Limestone, the verification of the reliability of the proposed workflow was presented and discussed in detail. Comparisons to traditional wettability estimations were also presented. A lively discussion of oil-wet scenarios followed the presentation.



DENVER CHAPTER
(Denver Well Logging Society, DWLS)

General News

Join us for the monthly DWLS meetings, which are held the third Tuesday each month, beginning in September and running through May. Meetings take place in the Mercantile Room at the Wynkoop Brewing Company in downtown Denver, Colorado. The networking social begins around 11:20 a.m., lunch is served at 11:45 a.m., and the technical presentation starts at noon. The cost for the DWLS luncheon is $25 and guests are welcome to attend. Visit the DWLS website at http://dwls.spwla.org to make your luncheon reservations, renew your membership, or join the society.

Recent Events

17 September 2019 – The September DWLS luncheon speaker was Natasa Mekic (Weatherford Wireline) who presented a talk titled, "Interpretation of Casedhole Pulsed-Neutron Logs in Complex and Unconventional Formations." The talk was well attended. The abstract and more information on Natasa Mekic can be found on the DWLS website in the newsletters - http://dwls.spwla.org/Newsletters.htm

DWLS September 2019 meeting. Speaker Natasa Mekic (Weatherford Wireline).

15 October 2019 – Don Herman (Cordax Evaluation Services) presented "Continuous Improvement of Well ROI.

DWLS October 2019 meeting. Speaker Don Herman (Cordax Evaluation Services).

22 October 2019 – DWLS/RMAG Fall Symposium was held at the Sheraton Denver West in Lakewood, Colorado. The symposium theme was "Multiscale Imaging for Reservoir Optimization." The talks including imaging techniques, analysis, and interpretation across a range of scales, from the pore scale to beyond the wellbore. Hot topics included Niobrara and Mowry reservoirs in the Powder River Basin, and Permian Basin reservoirs. The list of presentations is available at https://www.rmag.org/events/symposiums/.

EAST CHINA CHAPTER

Recent Events

24–27 September 2019 – The 11th UPC International Symposium on Well Logging Technology, hosted by the East China Chapter of SPWLA, was held in China University of Petroleum (East China). The symposium was a great success with total attendance exceeding 130. Attendees included representatives from international universities from the United States, Russia, Great Britain, and Australia; and from domestic universities, including China University of Petroleum (East China), China University of Petroleum (Beijing), China University of Geosciences (Beijing), University of Electronic Science and Technology of China, Jilin University, Yangtze University. Representatives included two SPWLA Distinguished Speakers, Dr. Lin Liang and Dr. Harry Xie, as well as representatives from various research institutes and petroleum services companies. Professor Marina Pervukhina from the Australian CSIRO and Elena Simonenko, director of Pomor-GERS in Russia,

gave the keynote reports on topics of current status and challenges in "Petrophysics" and "Logging Big Data", respectively. The UPC International Symposium on Well Logging Technologies is one of the most influential professional conferences in China. We are looking forward to the 12th UPC International Symposium on Well Logging Technology in 2020.

East China Chapter Logging Symposium. Harry Xie, serving as a SPWLA Distinguished Speaker, gave a special report.

East China Chapter Logging Symposium. Lin Liang, serving as a SPWLA Distinguished Speaker, gave a special report.

East China Chapter Logging Symposium. Professor Shumilov, serving at Perm State University, Russian Federation, is giving a special report.

FORMATION TESTING SIG

General News

We are welcoming Anup Hunnur (Baker Hughes) who has joined the Formation Testing SIG steering committee.

Recent Events

Completed the first three Webinar with speakers Dr. Christine Economides (University of Houston), Dr. Oliver Mullins (Schlumberger), and Colin Schroeder (University of Texas).

Upcoming Events

11 November 2019 – Next and last Webinar for this year. The speaker will be Camilo Gelvez (University of Texas).

07 May 2020 – The Annual Technical Conference will be held in Houston. Please stay connected to SPWLA media for the call for abstracts coming soon.

East China Chapter Logging Symposium. Group photo of conference attendees.

FRANCE CHAPTER

Recent Events

08 October 2019 – The Fall technical session took place in Paris at Société Géologique de France on with five talks about "Petrophysical Interpretation Software Solutions." All major software providers were represented (CGG with PowerLog, Emerson with Geolog, Lloyd's Register with Interactive Petrophysics and Schlumberger with Techlog) along with Voxaya that introduced Voxilon, a software to simulate rock properties from 3D microimages. The presentations were split into three subtopics:

(1) Machine learning, clustering and modelling: "Machine Learning for Better Wells," by Daria Lazareva (CGG GeoSoftware) and "Solving with DTA not Guessing: A Unique, Non-Statistical, Machine Learning Method for Curve Prediction," prepared by Ravi Arkalgud (Helio-Flare Ltd / Lloyd's Register) and presented by Ross Brackenridge (Lloyd's Register).

(2) Stochastic methods and uncertainty propagation: "Handling Uncertainty in Petrophysical Analysis with Geolog" by Nicolas Poete (Emerson).

(3) Advanced petrophysical interpretation solutions: "Challenging Laboratory Measurements – Contribution of Numerical Petrophysics" by Vanessa Herbert (Voxaya); and "Volumetric Inversion Methods With Integration of Advanced Log Measurements (NMR, Dielectric, Spectroscopy)" by Mounir Belouahchia (Schlumberger).

France Chapter October 2019 meeting. (Left) Daria Lazareva (CGG) opened the session with her presentation about machine learning in PowerLog; (center) Ross Brackenridge (Lloyd's Register) presented DTA within IP; (right) Nicolas Poete (Emerson) presented Geolog and covered the uncertainty topic.

In addition, opportunity was given to all software providers to make a 10-minute general demonstration of their software solution. The session, followed via weblink in parallel, was attended by consultants, universities, research institutes and representatives of operators and software companies. Discussions covered the use of machine learning, logging and laboratory data integration in current workflows as well as development orientations (integration, scripting facilities…).

France Chapter October 2019 meeting. (Left) Vanessa Hebert (Voxaya) presented the contribution of numerical petrophysics with Voxilon. (Right) Mounir Belouahchia (Schlumberger) closed the session with the integrated interpretation of advanced log measurements.

LONDON CHAPTER
(London Petrophysical Society, LPS)

General News

Our AGM is coming up in November and we are looking for volunteers to join the committee. Please get in touch with Mike Millar if you are interested – all are welcome!

Recent Events

12 September 2019 - We held an excellent One-Day Seminar on 'Life After Casing'. A huge thanks to all of our speakers, our attendees and to the committee for such a great day. Distributed temperature analysis is clearly a 'hot' topic,

plus there were some excellent talks and case studies on pulsed-neutron tools; downhole cameras; casing inspection and more.

15 October 2019 – The evening lecture was presented by Ebrahim Heydari (Independent) on "Rock Typing: Application in Reservoir Modelling and Development."

29 October 2019 – At the invitation of the University of Portsmouth School of Energy and Electronic Engineering, the LPS presented a workshop titled "An Introduction to Practical and Commercial Aspects of Petrophysics" during their Autumn Consolidation week. The LPS presented talks on petrophysical topics that are not normally covered in the University curriculum, which allowed the students to benefit from the experience of working practitioners in the field of formation evaluation and to gain insight into the skills used by petrophysicists in their work.

Upcoming Events

12 November 2019 – AGM and off-topic talk by Lambert Energy; Janet Watson Lecture Theatre, Geological Society, Piccadilly.

05 December – One Day seminar on 'Data Science'. Call for abstracts now open! Janet Watson Lecture Theatre, Geological Society, Piccadilly. President's Evening from 5:30 p.m. following the seminar; Kings Heads, Stafford Street

See our website www.lps.org.uk for details of all our events.

LPS September 2019 One-Day Seminar. Kamaljeet Singh (Schlumberger) presenting.

MALAYSIA CHAPTER
(Formation Evaluation Society of Malaysia, FESM)

General News

FESM, a local chapter of Formation Evaluation Society of Malaysia is based in Kuala Lumpur. Technical meetings are held on the fourth week of each month. For meeting information, please visit our chapter website at www.fesmkl.com.

Recent Events

15 August 2019 – FESM hosted two well-attended presentations:

"Waterflood Injectivity Loss—A Multidisciplinary Root Cause Case History" by Dr. Rick Lemanczyk (Three60 Energy). He described how a multidisciplinary approach, combining elements of production technology, core analysis, oilfield chemistry and geomechanics was adopted to understand water injectivity impairment in a sandstone reservoir onshore Indonesia. The second presentation was titled "Understanding Uncertainty in Sanding Potential for a Field with Limited Data" by Graeme Rae (GGRE). He presented the method on using limited sufficient data to reduce the levels of uncertainty.

FESM August 2019 meeting. (Left) Dr. Rick Lemanczyk (Three60 Energy) and Graeme Rae (GGRE) (right) receiving tokens of appreciation from FESM President, Mr. Thanapala.

THE NETHERLANDS CHAPTER
(Dutch Petrophysical Society, DPS)

Recent Events

19 September 2019 – DPS held a seminar with the theme "Petrophysics in the Digital World." Dr. Matthias Appel (Shell) presented on "Petrophysical Applications of Digital Rock Technologies," and Igor Kim (Shell) presented on "Introduction to Python for Petrophysics" with a new first for the DPS—a live demo of a Jupyter Notebook petrophysical model. The presented material and the executable notebook will become available on the DPS website. The meeting was well attended, and the audience engaged in livery discussion on both topics during and after the talk. DPS would like to thank all attendees and both speakers for an inspiring session.

Iulian Hulea (DPS president, left in each photo) presenting the speakers with a token of appreciation. Top, Matthias Appel; bottom Igor Kim)

DPS September 2019 meeting. Part of the engaged audience during the presentation by Matthias Appel (Shell).

PERMIAN BASIN CHAPTER

General News

The Permian Basin Chapter of SPWLA generally holds meeting on the last Tuesday of the month at Midland College. Our attendance has steadily increased as our new board members have started reaching out to their individual networks. We are currently looking for someone who would like to pick up the role as Interim President, but we are doing well picking up the excess responsibility for now.

New Chapter Officers

President	Currently looking for candidates
Vice President	Amine Chenaf (Concho)
Secretary	Alexis Iwasiw (Cordax)
Treasurer	Ross Klabon (Weatherford)
WebMaster	Zach Mueller (Apache)

Recent Events

27 August 2019 – To start out the year, we had a social happy hour event at the Blue Door, sponsored by Premier Oilfield Group. With their donation, we were able to provide both drinks and appetizers to our society members at the social at no charge. We had a great turnout as members who left the Permian, returned and rejoined the society.

16 September 2019 – The Chapter had a luncheon at the Midland College Carrasco Room on Monday to avoid conflict with the WTGS Symposium. Our speaker was Abhijit Mitra (Geomechanics Consultant at MetaRock Laboratories) who presented "Core-Based Measurement for Improved Petrophysical Assessment and Hydraulic

Fracture Design." In his talk he reviewed the importance of understanding the variable lithofacies of the Permian using both field measurements, such as seismic and sonic data, and key core-based measurements to obtain more insight on the permeability and its variation with stress with each lithofacies, as well learning more about the mechanical and poroelastic behaviors of each lithofacies.

29 October 2019 – Dave Cannon (VP of Geosciences, Diamondback) discussed a project the geologists at Diamondback have been working on.

Permian Basin Chapter September 2019 meeting. (Left) Amine Chenaf, chapter Vice President thanking our Abhijit Mitra and presenting him with our speaker's award.

SAUDI ARABIA CHAPTER (SAC)

Recent Events

04 September 2019 – At the monthly technical luncheon technical talks on "Objective Driven Coring for Retention of Reservoirs Fluids" were given by Samir El-Beshbishy (Reservoir Group) and David Wunch (CORSYDE). Technologies of liquid trapper and pressure coring were discussed. Great discussions were focused on advantages and disadvantages of these two methods.

SAC September 2019 meeting.

SAC September 2019 meeting.

Upcoming Events

November 2019 – Additional interesting events are in the planning stages, including a workshop on Petrophysical Applications of Geochemistry. Please stay tuned to our chapter website for details (spwla-saudi.org) and event announcements will be sending out as usual.

TEXAS A&M UNIVERSITY KINGSVILLE (TAMUK) STUDENT CHAPTER

General News

The request for registration of the Society of Petrophysicists and Well Log Analysts TAMUK was approved by the University authority. We have more graduate students, and so we are working on getting undergraduates students to sign up. We are in the formative stage, so more brainstorming is being done on how to expand.

Recent Events

17 October 2019 – The TAMUK Student Chapter had a display at the recently held Earth Science Day at the Physics and Geoscience Department Texas A&M University Kingsville. Some of the physics and geoscience students passed through our exhibitions, which include digital display of well logs and cores. We spent time explaining what we do as petrophysicists, e.g., interpret the displayed logs and cores. We also discussed well logging, wireline and LWD tools.

TAMUK 2019 Earth Science Day. Visual core description by Ajibola Samo at Geoscience Library.

TAMUK 2019 Earth Science Day. Howard R. August Palacios explains well logs to geoscience students at the Physics & Geoscience Library.

TAMUK 2019 Earth Science Day. TAMUK group picture: (Left to right) Howard Palacios, Sterling Decal, Toluwalope Bamisile, Ajibola Samo, Monica M. Estrada.

TULSA CHAPTER

General News

The bimonthly luncheon meetings are held on the second Thursday of alternate months, beginning September 12, 2019, The University of Tulsa, Room 121 of Helmerich Hall, 800 South Tucker Drive, Tulsa, Oklahoma, 74104. Meeting times are at 11:30 a.m. to 1:30 p.m.

The 2019–2020 Chapter officers are

President	Elizabeth Dickinson
Vice President of Technology	Maureen McCollum
Treasurer/Secretary	Patrick Ryan

Recent Events

12 September 2019 –The first meeting of the Tulsa Chapter new season was well-attended with a full house for James Howard's presentation on "Machine Learning Methods: Analysis of Rock Images and Beyond." We had several people drive all the way from Norman, Oklahoma, and from Oklahoma City, Oklahoma to attend.

Tulsa Chapter September 2019 meeting. James J. Howard (DigiM Solution) presenting.

Upcoming Events

14 November 2019 – Paul Craddock (Schlumberger) will be presenting his work on "Thermal Maturity-Adjusted Log Interpretation (TMALI) in Organic Shales."

12 December 2019 – The Chapter's first social event will be held at Roosevelt's on Cherry Street, in Tulsa at 6 p.m. Please join us as we gather to sample the goodness offered by this fine establishment and appreciate the fine company of our friends and colleagues. Bring a friend!

Reach out to us with any questions you may have regarding membership in SPWLA, our luncheon meetings and distinguished speakers, or just drop us a message and let us know how you are and what you are doing. We would love to hear from you! Our email address is tulsa.chapter@spwla.org or you can send a letter to our post office box at SPWLA Tulsa Chapter, PO Box 14495, Tulsa OK 74104-9998

THE UNIVERSITY OF TEXAS AT AUSTIN STUDENT CHAPTER

General News

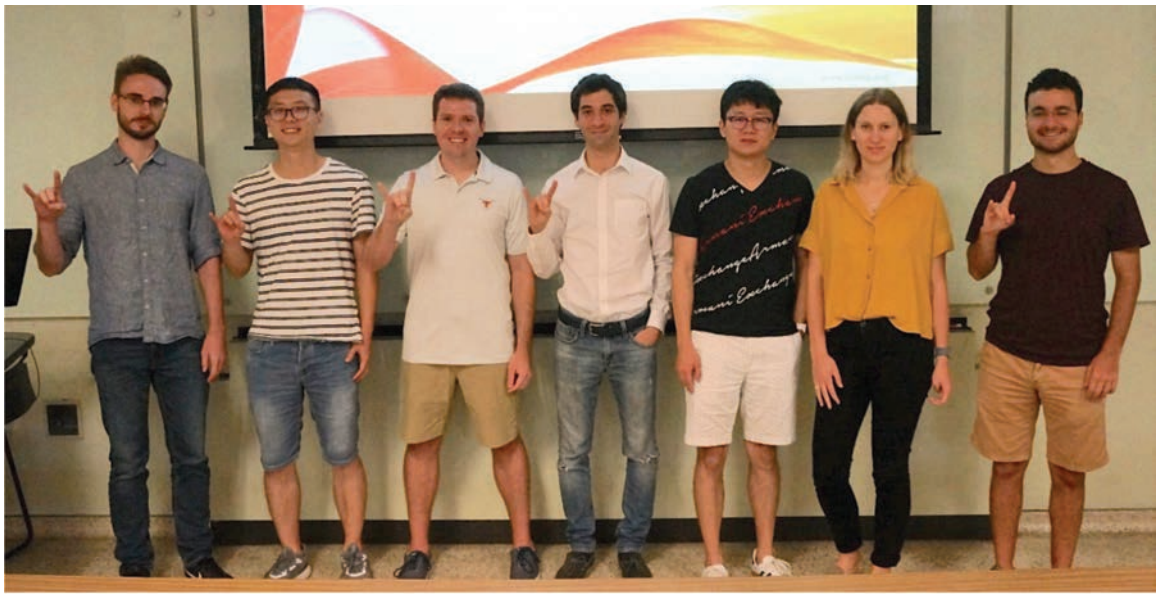
School is back in session at UT-Austin, and the Student Chapter of SPWLA has been working hard to recruit new members and plan events for the 2019–2020 school year. This year, we have three new officers: Pierre Aerens (Treasurer), Camilo Gelvez (Social Media Manager), and Daria Olszowska (Special Event Coordinator). We have held one special event and several technical seminars are scheduled.

Recent Events

04 October 2019 – The chapter hosted a special event with two speakers from UT Austin. Last year's student paper contest winner Sercan Gul presented his award-winning work entitled "Automated Surface Measurements of Drilling Fluid Properties: Field Application in the Permian Basin." We also invited SPWLA 2019–2020 SPWLA Distinguished Speaker Colin Schroeder, to present his recent work "Experimental Investigation of Mud-filtrate Invasion Using Rapid Micro-CT Imaging." The talks were very well-attended, and we would like to thank Sercan and Colin for sharing their excellent research work with the graduate student community at UT Austin!

Upcoming Events

28 February 2020 – Melanie Durand (Shell) a 2019–2020 SPWLA Distinguished Speaker will give a technical presentation entitled, "Crushed Rock Analysis Workflow Based on Advanced Fluid Characterization for Improved Interpretation of Core Data." We would like to thank Melanie and Shell, and we are really looking forward to the technical presentation!



UT Austin student chapter October 2019 meeting. Officers of the Student Chapter with the speakers. Left to right: Pierre Aerens (Treasurer), Wen Pan (Webmaster), Colin Schroeder (Speaker, 2019–2020 SPWLA Distinguished Speaker), Sercan Gul (Speaker, 1st place in 2019–2020 SPWLA international student paper contest), Tianqi Deng (President), Daria Olszowska (Special Events Coordinator), and Mohamed Bennis (Vice President).

Recent Accolades

Two SPWLA members received awards at the recent SPE Annual Technical Conference and Exhibition in Calgary, Alberta, Canada:

Carlos Torres-Verdin, Professor in the Hildebrand Department Petroleum and Geosystems Engineering at the University of Texas at Austin, was awarded the SPE/AIME Anthony F. Lucas Gold Medal "for his extraordinary scientific contributions to the industry in the realm of geophysical measurements and reservoir characterization, and developing groundbreaking methods for the petrophyslcal interpretation of multiple well logs that have been successfully adopted by service and operating companies." This is SPE's major technical award. It recognizes those responsible for developing new technology and concepts and demonstrating distinguished achievement in improving the technique and practice of finding and producing petroleum.

Zoya Heidari, Associate Professor in the Hildebrand Department Petroleum and Geosystems Engineering at the University of Texas at Austin, together with former PhD student, Lu Chi, is the recipient of the 2019 AIME Rossiter W. Raymond Memorial Award for their paper "Directional-Permeability Assessment in Formations With Complex Pore Geometry With a New Nuclear-Magnetic-Resonance-Based Permeability Model." The award recognizes the best paper published by AIME in a given period where the lead author is a member under 35 years of age.

In addition, Zoya was awarded the SPE Distinguished Membership Award, which "acknowledges members who have attained eminence in the petroleum industry or the academic community, or who have made significant contributions to SPE."

Separately, Zoya is also the recipient of the 2019 EAGE Arie van Weelden Award, which is "presented to a member of EAGE who has made a highly significant contribution to one or more of the disciplines in our Association and who qualifies as an EAGE Young Professional (a geoscientist or engineer aged 35 or below) at the time of their nomination."

Marvin Gearhart
1927–2019

Marvin Gearhart was a pioneer in both drilling and well logging. The overlap especially occurred with measurement-while-drilling (MWD) technology that Marvin, along with Teleco, championed and led in development. In addition to MWD, Marvin's company was the first to commercialize a computer-based digital logging system, the DDL system in 1975. Other achievements include ULTRA optimization petrophysics evaluation software, the six-arm dipmeter tool and SHIVA dipmeter analysis software, and the High-Resolution Induction tool, arguably the first widely accepted array induction service. Gearhart's companies were also leaders in manufacturing equipment used by service providers around the world.

Marvin was the son of a farmer who worked on pump jacks and gave his son his first lessons on checking and fixing the machines twice daily at an early age of three or four. After graduating high school Marvin joined the U.S. Army. He stood out for his mechanical skills and the Army recommended that he take part in a college program that took him to Michigan State University and Colorado School of Mines. His learning was taking place as World War II was ending. He received his degree in mechanical engineering at Kansas State in 1949 and began his career in the oil and gas industry at 22 years old, landing his first job with Welex Jet Services in Fort Worth, Texas. Marvin became a legend in the global industry through his ingenuity mixed with a competitive spirit.

Marvin met Harrold Owen, a physics major from TCU, and the two became friends and business partners. In 1955, the two men established Gearhart-Owen Industries, Inc. A company that grew to become the world's third largest oilfield services company (and a leader in manufacturing equipment used by service providers around the world), evolving into Gearhart Industries Inc. and would later be acquired by Halliburton in 1988. He started two smaller companies Rock Bit International and GeoLink before his retirement. The Society of Professional Engineers (SPE) recognized his contributions to drilling by awarding him the 2014 Anthony Lucas Award.

Marvin joined SPWLA in 1965 and received Honorary Membership in 1985, the Distinguished Service Award in 1986, and the Pioneer Award in 2016 (only the third recipient following Conrad and Marcel Schlumberger). Marvin was a generous supporter of SPWLA, best known for hosting the Golf Tournaments at Annual Symposiums with a large cash prize payout for a hole in one.

Marvin supported starting an engineering program at TCU in the 1990s. He is remembered in the industry as a humble and selfless leader and for his timeless contributions.

Marvin, died at the age of 92, just weeks after his wife of 72 years, Jo Anne Gearhart died. He is survived by four children and their spouses; 13 grandchildren and 14 great-grandchildren.

Welcome New Members: August 15, 2019–October 14, 2019

Botchway, Kodjo, Texas Tech University, Lubbock, TX, United States
Buendia Lombana, Hernando, Ecopetrol, Floridablanca, Santander, Colombia
Carrillo, Luis, Universidad Industrial De Santander, Bucaramanga, Santander, Colombia
Davis, Byron, Basin Oil & Gas, Fort Worth, TX, United States
Duodu, Godfried, Texas Tech University, Lubbock, TX, United States
Enright, Scott, Texas A&M, Lufkin, TX, United States
Espeli, Susanne, University of Stavanger, Stavanger, Norway
Fonseca, Paola, CGG, Richmond, TX, United States
Gland, Nicolas, IFPen, Rueil-Malmaison, France
Guo, Zhaoquan, China University of Petroleum Beijing, Beijing, Changping, China
Haddad, ELia, Schlumberger, Houston, TX, United States
Hambissa, Hana Yonas, University of Portsmouth, Southsea, Hampshire, United Kingdom
Lutfullin, Arthur, BHGE, Victoria Park, WA, Australia
Maksimova, Elizaveta, Gazpromneft Scientific Technical Center, Saint Petersburg, Russian Federation
Meng, Yue, Massachusetts Institute of Technology, Cambridge, MA, United States
Oduah, Chinwe, Southern Alberta Institute of Technology, Calgary, AB, Canada
Olszowska, Daria, University of Texas at Austin, Austin, TX, United States
Ortego, Andrew, Halliburton, Lafayette, LA, United States
Pathak, Sunita, Texas Tech University, Lubbock, TX, United States
Peevy, Christen, Kinder Morgan, Houston, TX, United States
Prado, Roxiris, Halliburton, Quito, Ecuador
Primkulov, Bauyrzhan, MIT, Cambridge, MA, United States
Reynaud, Carole, CVA International, Biot, Sans objet, France
Segun, Oladele, Federal University of Technology Akure, Agege, Lagos, Nigeria
Siegert, Juan, Schlumberger, Midland, TX, United States
Sims, Mitchell, PRI Operating, Amarillo, TX, United States
Slayden, Jason, XTO Energy, Spring, TX, United States
Smith, Sebastian, Texas A&M University, College Station, TX, United States
Stricker, Kai, Karlsruhe Institute of Technology, Schluchsee, Baden-Württembe, Germany
Talipov, Rustem, IGiRGI, Moscow, Russia
Vielma, Ana, University of Houston, Houston, TX, United States
Wheeler, Josephine, Shell, London, United Kingdom
Wu, Jiwei, Harvard University, Cambridge, MA, United States
Zargar, Zeinab, University of Houston, Houston, TX, United States
Zhang, Panpan, China University of Petroleum, Beijing, China