ISSUE 3 | VOL 2 | MAY 2019

THE SPWLA TODAY NEWSLETTER

Petrophysics Education in Brazil

INSIDE THIS EDITION

The Society of Petrophysicists and Well Log Analysts Board of Directors 2018–2019

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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

April 29–30, 2019
2019 SPWLA Spring Beijing Workshop
Theme: Digital Rock, Pore Structure and Dynamics: Physics, Methods and AI
Beijing, China
www.spwla2019.com

June 15–19, 2019
SPWLA 60th Annual Logging Symposium
The Woodlands Waterway Marriott
The Woodlands, Texas, USA
www.spwla2019.com

June 20, 2019
SPWLA PDDA 2019 SIG Meeting
Theme: Machine Learning, Deep Learning, Artificial Intelligence, Petrophysical Interpretation, Reservoir Characterization
Anadarko Corporation Headquarters
The Woodlands, Texas, USA
www.spwla.org

June 20–21, 2019
SPWLA NMR SIG Conference 2019
Theme: NMR Today and Tomorrow: Downhole, at the Wellsite and in the Lab
Southwestern Energy
Spring, Texas, USA
www.spwla.org

September 16–19, 2019
The 11th UPC International Symposium
Theme: "New Well Logging Techniques"
School of Geosciences – China University of Petroleum (East China)
Qingdao, China
www.spwla.org

September 25–26, 2019
The 25th Formation Evaluation Symposium of Japan
JOGMEC-TRC
Hostess by Japan Formation Evaluation Society – A Chapter of SPWLA
Chiba, Japan
https://jfes-spwla.org/symposium

About the Cover

This issue focuses on petrophysical education in Brazil.

See the article by Professor Abel Carrasquilla on page 16.

SPWLA 2019
SYMPOSIUM

JOIN US

60th ANNUAL SYMPOSIUM

Society of Petrophysicists and Well Log Analysts

June 15-19, 2019

REGISTER TODAY www.spwla.org

SOCIETY OF PETROPHYSICISTS AND WELL LOG ANALYSTS


Celebrating
60 Years!
SOCIETY OF
PETROPHYSICISTS AND WELL LOG ANALYSTS

From the President

Zhipeng "Zach" Liu
2018–2019 SPWLA President
zliu@spwla.org

Dear Fellow SPWLA Members and Friends,

As the old saying goes, "Time flies when you're having fun." This is my last column as your president. It has been a pleasure and an honor to have the membership elect me and put your trust in my abilities to run our organization in our 60th year. What a transformative year for SPWLA! I would like to thank my board (Jesus, Jim, Katerina, Carlos, Jennifer, Mehrnoosh, Adam, Doug, Mike, Mark, Nadege, and Rick), and also our business office staff (Sharon, and Stephanie) for their diligent work this year. A round of applause for the board as they worked hard, were professional, and, at the same time, understood the gravity of the situation amid the prolonged industry downturn.

Following the successful London symposium, I met and worked with chapter officers, many members, students and young professionals around the world to wrap up the charter process with greater flexibility to accommodate chapter-specific issues. The charter process is nearly complete for chapters and SIGs. With the trust of SPWLA Board restored among the chapters, SPWLA and its chapters are united to better serve our members and the petrophysics community. Even during this difficult year, SPWLA was able to achieve growth this past year. We added/reinstated PDDA, Education, the HAHZ SIGs, reinstated Tulsa and Colombia chapters; and, we also added a few new student chapters around the world. On the financial side, we deliberated many options. The board improved the expense spending and kept the finances stable despite the weaker revenue. For example, we cut the board travel, legal, business office expenses, and reallocated the funds to other productive programs for members, such as webinars, student chapter support, distinguished speakers, and to *Petrophysics Journal* and *SPWLA Today*. The board also allocated substantially more funding to support improving the *Petrophysics Journal*, whose influence index has risen in recent years. On the membership side, we introduced a lifetime membership for senior members which was very well received. As of April, we have 99 lifetime members.

This year was not without challenges. Commodity prices are continuing to affect our members around the world—no one is immune to low prices. Associations like SPWLA—who rely on providing products and services to our members by connecting the industry professionals and vendors to our members—are still facing difficult times. The decline in sponsorship and advertisement has presented great challenges for our society. We especially appreciate, and thank, the sponsoring companies who graciously supported SPWLA this year. We look forward to collaboration with additional companies in the future. Last year's obsolete election tiebreaker criteria caused some controversy. SPWLA's bylaw was swiftly amended to bring the tiebreaker criteria in line with modern society values. The board had to maintain a balance between expanding *Petrophysics Journal* articles and managing associated costs, at the same time that advertisement revenue decreased. Lastly, the divisiveness of daily partisan politics managed to find its way into SPWLA in recent years. Understanding the other side's point of view, even if one disagrees with it, is central to compromise, policymaking and civility. Sometimes, the polarization has gotten personal, preventing us from working together as a cohesive team to find compromised practical and sensible solutions to best serve the noble SPWLA cause, which is why we volunteer in the first place.

My best wishes to my successor Jesus Salazar and the incoming 2019–2020 board in their efforts to implement new agendas, promote innovative ideas and overcome challenges that still lie ahead. The future for SPWLA is bright. SPWLA as a group is strong and enduring. We will get through the tough times and look back and tell stories of the prolonged downturn in our industry with less of an ache than we feel today.

Looking ahead with optimism and excitement, I want to end this column on a positive note. The 60th annual symposium is just around the corner. Let me tell you…***HOUSTON IS READY FOR YOU***! The organizing committee has been hard at work and planned many interesting programs. The opening weekend plays host to two field trips, a variety of short courses and the student paper competition. Monday morning is set to begin with technical presentations and the exhibition with the afternoon reserved to honor achievements of your peers at the annual awards luncheon. This year, for the first time, the Tuesday technical programs will contain dual, concurrent sessions. Don't miss out on a workshop as we have eight from which to choose, and a few of SIG meetings held around the symposium time. Social events are a plenty beginning with the icebreaker hosted by Halliburton on Sunday evening. End your Monday with an invitation from Baker Hughes to join them for a social evening. Top off your Tuesday with the final social hosted by Schlumberger. While the delegates are at the symposium, their families can pick from an assortment of wonderful activities that include Texas tours, shopping, dining, a winery excursion, experience the finest hand-made Venezuelan organic Criollo chocolates, or wander through the George Herbert Walker Bush Presidential Library. Also available is a Hospitality Suite available for lounging, socializing and snacking. I would like to extend a personal invitation to you and your colleagues to attend this symposium. Like many other past presidents, I do not plan to end my volunteering, there are always roles to fill in the SWPLA. With that said, I will see you in Houston in June.

Best,
Zhipeng "Zach" Liu, P.E.

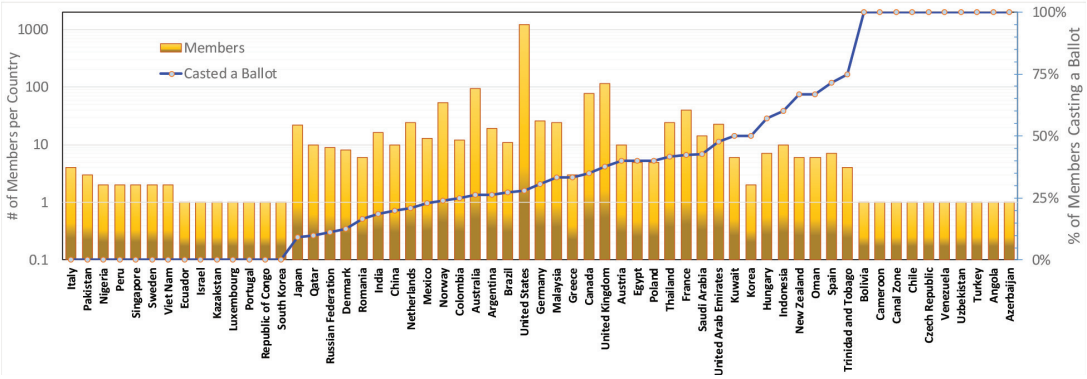
Jesús M. Salazar
2018–2019 SPWLA
President-Elect

This is my last column as President-Elect. In July, I'll have the privilege of writing my first *From the President* letter. It'll be a little more work because the President has to write a column for every issue. I tell you what, a lot of stuff happens in the background (aka board meetings) that there's always plenty of material to write about. We're only couple of weeks away from the 2019 Symposium and I cannot wait to start working with the new Board of Directors that will be installed during the annual business meeting. A friendly reminder that anyone can attend to the business meeting. Also, remember that tickets are first come first served, so, I encourage everyone to register early and request a ticket to attend the meeting and other social activities, including the awards ceremony and icebreaker.

Speaking of new board members, I'd like to talk about the election process. Every year, the Past President (previous year s president) is in charge of creating a nominating committee and soliciting candidates to run for office. Traditionally, this has been an organic process where most of the nominees have previously served in local chapter's committees and the candidates for President-Elect are returning board members. This process created a pool of two or (rarely) three candidates running for each position in the ballot. However, like in government politics, none of this is a requirement but helped keep the process simple and recruit candidates with a proven record of volunteerism. This year the process was open to every member of the society using the clause that you can nominate yourself as long as you have 10 SPWLA members backing you up. This created a diverse but crowded ballot with candidates from several companies. I'll spare you the details and will refer you back to an email sent by Sharon (October, 25, 2018) on behalf of the Past President soliciting self-nominations. It'll be up to our current President to keep this year's process or revert back to the old system for the 2020 elections (no, not the US elections). We will certainly keep you informed. This year, one of the caveats associated with using this model actually happened, one company was overrepresented and we had to inform the winner of one position that he led the ballot but the runner-up was the winner. This is an awkward position to be, for both, the lead nominee and the Past President who has to break the bad news. Nevertheless, the rules were made available to everyone and I hope that this year's candidates are still willing to run again next year. I was defeated in two elections myself before being voted to be on the board as VP Technology a few years ago, so keep on trying.

Continuing with the election topic, I'm going to make a call to our membership to have a more active role in the society. You should make a habit of using all the benefits of the SPWLA. One of the most important benefit is the right to vote. In the last election, only 589 ballots were cast out of 1978 paid members, yielding a 30% participation rate or 70% abstention if you want to sound more dramatic. I believe we can do better, we don't like to bombard your inbox with emails that you may not read, but will be more persistent in reminding you to cast a ballot next March.

We gathered some stats from last election that I'm sharing with you all. The graph below shows the number of members per country (logarithmic scale) compared to the rate of participation in the election process. As expected, the United States has the largest number of members and it's driving the average of participation with their 28% very similar to the global average. I would like to especially thank the members from countries that had a participation above 40%, we need that enthusiasm to keep moving forward in our society and welcome participation from all over the world.



Number of members per country (as of March 31, 2019) compared to rate of participation in the 2019 BOD election. It is Interesting to see that the number of members plotted with growing percentage of participation looks like a resistivity log with the shale baseline hovering around 1 Ω.m. The USA bar looks like a calcite cement tight streak. Isn't it wonderful? We certainly need to increase resistivity!

In other activities as President-Elect I was kindly invited to present at the University of Texas at Austin Student Chapter on February 15 and at the Denver Well Logging Society (DWLS) (an SPWLA Chapter) on February 19. The presentation included a quick overview of the SPWLA mission, benefits to membership, and progress in the last couple of years following by a technical presentation on source-rock petrophysics. I want to thank UT-Austin Student Chapter President Artur Posenato Garcia and VP Technology of the DWLS, Dr. Patricia Rodrigues for the invitations. Additionally, during my visit to Colorado I was invited by Professor Manika Prassad to the Colorado School of Mines to her Well Logging Interpretation class, I had the honor to teach a two-hour seminar on dielectric logging and applications and the opportunity to talk to students about the SPWLA. I enjoyed spending time with the students talking about the oil and gas industry and a career in petrophysics. It was a very rewarding experience. As usual, below find a couple of pictures of my chapter visits during the first quarter of 2019.

Presenting to the SPWLA Student Chapter at my Alma Mater, the University of Texas at Austin.

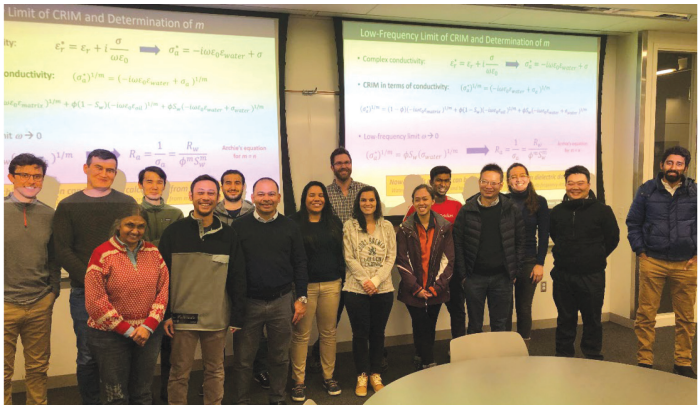


Photo with Petroleum Engineering graduate students in Colorado School of Mines after teaching an invited lecture on dielectrics, Professor Prassad is in the first row in the red sweater,

Posing with graduate students in the iconic well heads outside of the Hildebrand Department of Petroleum Engineering. I even brought my family to get the kids excited about science and engineering. Needless to say that we enjoy spending weekends in Austin.

A selfie after receiving the presenter token at the DWLS monthly seminar.

Regional Understandings – Europe

Mike Webster
Europe Regional Director

My two-year term of office as European Director is rapidly coming to an end and I will shortly be handing the baton over to Craig Lindsay.

It has been fascinating to see how the SPWLA organisation works and a privilege to have a seat at the table and help influence its direction. There is an enormous amount of work that goes on behind the scenes to keep things running smoothly. All of this is driven by enthusiastic volunteers who dedicate their time and energy for the benefit of our society. As this is a global organisation, many of the board meetings were held at times when time zones dictated participation into the small hours of the morning which demonstrated exceptional dedication.

Board meetings were always interesting. The diversity of views and opinions generated some robust debates. The common unifying goal was to make SPWLA a vehicle for the sharing and exchange of knowledge for the benefit of its members. I would encourage others who feel they have something to contribute to stand for election and support SPWLA. Our industry and technology is continually changing, and we need to respond to these changes to keep the society current and relevant.

Thanks for giving me the opportunity to serve. I'm sure Craig Lindsay will bring fresh enthusiasm and ideas to the table to help drive us forward.

Mike Webster

Regional Understandings – Asia Pacific

Rick Aldred
Regional Director
Asia Pacific

My term of office as Asia Pacific region director for the SPWLA concludes in June, so this will be my last column for this newsletter. It has been a very interesting experience serving on the board, but I will not miss the web-based board meetings which take place every two months, starting at either 11 p.m. or midnight my time and going on for a few hours. It is very difficult to make meaningful contributions in those meetings after being awake and working for 16 or 17 hours before they even start! I wish the best of luck for next year to Tom Neville, the new VP Publications, who lives in the same time zone as me!

It is nice to see that the region's name has gradually been changed from the awkward and inaccurate 'Asia and Australia' to the more commonly used and accepted region name of 'Asia Pacific', covering the area from India and China, through East and Southeast Asia to Australia and New Zealand.

One thing that I have been very keen on during my term of office is the promotion and advancement of the value of petrophysics and of our society in the region. For this reason, I am keen to see the SPWLA Asia Pacific Regional Conferences continue and grow into a regular event on the calendar, rotating between interested chapters. I have asked the chapter presidents in the region and the Bangkok Chapter is the most keen to hold the next one, hopefully repeating the success of their conference in 2016.

The best date for this appears to be around late February or early March, 2020. The Bangkok Chapter president, Andrew Cox, and I have already started to make plans and we welcome any expressions of interest from members in the region who would like to contribute to organizing the event. Once the final date has been selected we will let everyone know and call for abstracts soon.

We envisage the format will be similar to 2016, with a 'field trip' and social day, a 'new technology day' for service companies to showcase their wares in exchange for a small contribution to the costs, followed by two days of formal technical presentations. This time the authors will also be given the opportunity to publish their papers through the SPWLA via OnePetro.

Considering the interest in such conferences that I have heard around the region, and the success of the last two, in Bangkok in 2016 and in Indonesia last year, I'm sure this event will be very popular.

Where I can, I intend to stay involved, both with the regional conferences and in the society, but I now transfer the regional directorship to the capable hands of Jennifer Market for the next two years. I am sure chapters in the region will prosper during her tenure.

Rick Aldred

Regional Understandings – Latin America

Nadege Bize Forest
2018-2020 Latin America
Regional Director
director-la@spwla.org

Dear SPWLA Members,

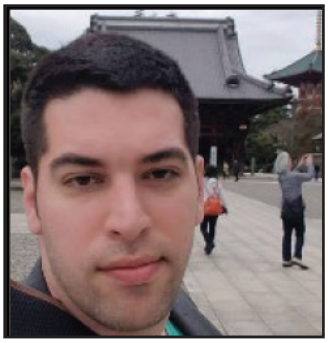
First, I would like to thank all Chapter board members of Latin America and Worldwide for volunteering and shining the SPWLA spirit within our Oil & Gas industry, professional communities and our universities.

Latin America now includes two affiliated and active professional chapters, in Argentina and Brazil, and two student chapters, in Brazil (UFRJ) and Colombia (UIS). Soon, we expect the affiliation of two new student chapters in Brazil. Colombia and Mexico professional chapters are also ready to start their activity and they ask for volunteering to consolidate their board. If you are interested to be part of these local chapter boards, please don't hesitate to contact me at: director-la@spwla.org

Finally, I will be pleased to meet you at the SPWLA Annual Logging Symposium, being held in Houston, in June, to discuss the Latin America SPWLA activities and engagement.

Yours Sincerely,
Nadine Bize Forest

Regional Understandings – North America 1



Adam Haecker
Regional Director
North America 1

This will be my final column of the 2018–2019 term but you aren't rid of me yet! I still have one more year on the board. I wanted to share a few recent events that might be of interest to the membership. But before that, would like to thank the outgoing members of the board for their service.

First, the chapter committee in Tulsa is very active. They are making great strides to get the chapter up and running again. The Board recently approved their petition for re-instatement and there should be chapter meetings starting in September. The downturn hit that chapter especially hard and they were unable to continue after 2015 with the level of interest they had at the time. However, like a phoenix, they have rose from the ashes and the new Chapter officers have selected the University of Tulsa as their meeting place. Some of you familiar with Tulsa might wonder "If I attend, where am I going to park?" Never fear, they have a system setup for parking, always a struggle at universities. If you RSVP in advance you can get free parking, if you don't though, you will have to pay. I will be attending the first meeting to show the greater societies support to their efforts so I hope to see you there if you live in the Tulsa area.

The second thing I wanted to discuss is the recent election. Once again, we have had some election drama in the SPWLA. There was a lot of interest from different candidates this year which is great for the society. However, too many Schlumberger folks won positions on the board. The bylaws have long had a provision that if more than three people from the same company win election, the most junior position, in this case regional director, will be given to the runner up. This was put in place to keep the SPWLA from becoming dominated by one company. Therefore, in the recent election, there was a shuffle after the fact in NA Director 2. The reason I bring all this up is not to stir the pot or call the results into question, but to point out that your vote matters. Please consider voting next year. We have around 2,000 active members and less than a quarter voted in the recent board election. We had an excellent slate of candidates this year thanks in part to the great work of the nominating committee. Please consider taking the time to vote in next year's board elections. Also, if you have considered running for the board please let people who work on the nominating committee know! Zach, our current and outgoing president will be heading up that effort.

The third thing I wanted to discuss is awards. There was some consternation on the board recently about awards. None of the candidates recommended by the awards committee were unworthy, however there was much discussion about lack of

diversity. There is *a lot of hair* on this subject. If we promote diversity too much we could end up discriminating in the opposite direction. However, I think most of us can agree the Society benefits from a diverse group of people participating and that a reasonable effort should be made to promote a diverse slate of award candidates. I would personally like to see more nominations of people outside of Houston, our international brethren, and women in our society. If you know a worthy person who has either shown outstanding technical merit or meritorious service please consider nominating them for an award for next year. It is never too early. Even if you don't want to put an application together, perhaps mention a name to the awards committee which is headed by past presidents of the Society.

The fourth thing I would like to highlight is bylaws. We are currently in the process of making recommendations to change the bylaws based on some recent issues that have cropped up this year. If you have something you would like to be changed please point it out to one of board members. Most of the changes we are considering are designed to constrain certain board positions ability to promote themselves. This has not really been an issue in the past since most, if not all board members, have high personal integrity, however the optics on certain events have not been good. Therefore, we are proposing some changes for the society to consider. If you have an idea on how we could make the Society better please don't hesitate to reach out.

Lastly, I want to congratulate my Student chapters this year. I have seen tremendous growth in our student chapters. UT, TTU, OU and U of H have all done an outstanding job promoting the society to students in formation evaluation. By the time you read this there will be a new slate of officers at each student chapter. Your new officers have big shoes to fill, but I expect you will be up to the task. Please stay in contact. Finally, Congratulations are in order for the University of Texas chapter. In a very close race, they were selected by the board as outstanding student chapter for the second year in a row. Keep up the good work you guys.

Excelsior,
Adam Haecker

P.S. It is spring and the Cherry blossoms are in bloom in Washington and Japan. Always a great time to be alive.

Katerina Yared
Vice President Education

Spring has sprung dear SPWLA aficionados!

Our Annual Logging Symposium is about a month away and I am very excited about the enthusiasm we have received from our SPWLA students from around the world to participate at the International Student Paper Competition on June 16th. We have received 35+ submission and accepted about half of them. I want to thank our committee judges for rating the abstracts. My biggest Thank You goes to our ISPC chair, Jiaxin Wang, for an outstanding job keeping us all on track and getting the ISPC organized and off to a great start.

Our Regional Distinguished Speakers and our Distinguished Speakers are our Holy Grail of knowledge! And I encourage you to use this exclusive resource SPWLA provides to your chapter. We had our speakers travel the world to visit and deliver firsthand exceptional knowledge sharing to our chapters. They went to chapters in the UK, France, Colombia, Qatar, Norway and many cities in the USA. We are accepting nominations for regional distinguished speakers every day!

So, send us your nominations. If you want to get any of our speakers to come visit your chapter, please find the list of speakers and their contact information here:
https://www.spwla.org/SPWLA/Chapters_SIGs/Distinguished_Speaker_List/SPWLA/Annual_Symposium/Distinguished_Speakers/Distinguished_Speaker_List.aspx?hkey=360f599e-0caf-45c3-a28f-dafb6a65ad29

Our monthly webinar series is open to non-SPWLA members now! Let all your friends and colleagues know that now it got easier to participate and join our Distinguished Speakers webinar series at a nominal fee of $25.

The next webinar speakers are as follows:

Date	Speaker	Title
May 7 and 8	Nicholas Bennett (Schlumberger)	Borehole Acoustic Imaging Using 3D STC and Ray Tracing to Determine Far-Field Reflector Dip and Azimuth
June 10 and 11	Hani Elshahawi (Shell)	Novel Smart Cement for Improved Well Integrity Evaluation

Don't miss them and make a note in your calendars!

Our "SPWLA Nuggets of Wisdom" series started off with Dick Merkle's favorite topic "Electrical Properties of Clay." He captured years of knowledge on that topic in a short "nugget" for our members to view and refresh anytime. Available now on our webpage www.spwla.org. Contact me with your "nuggets of wisdom" ideas at VP-Education@spwla.org.

Do you feel the desire to share your knowledge with the rest of the world? Contact me and we can see how we can help you. Teach a class in person or have people attend your training classes via web conference. We can make it happen!

See you in The Woodlands!

Sincerely,
Katerina Yared
VP Education (2018–2020)

SPWLA SIXTH BOARD OF DIRECTORS MEETING
REMOTE
HOUSTON, TEXAS
April 3, 2019

President Zach Liu called the meeting to order at 8:10 a.m. Attending remotely President-Elect, Dr. Jesus Salazar, VP Technology, Jim Hemingway, VP IT, Mehrnoosh Saneifar, VP Finance, Secretary and Administration, Jennifer Market, VP Publications, Dr. Carlos Torres-Verdin, Regional Directors, NA 1, Adam Haecker, NA 2, Doug Patterson, Latin America, Dr. Nadege Bize Forest, Europe, Mike Webster, Asia Pacific/ Australia, Rick Aldred, and Executive Director, Sharon Johnson.

A motion made by Doug Patterson to approve the proposal by Dr. Jesus Salazar to revise the membership dues wording Tier II Membership to Professional Member Group II and income based to country based. This $40. dues level has the same requirements and benefits as a Professional Member. The objective of this category is to alleviate the financial burden on members whose payroll country is within the UN metrics. Members in transition from any country may also fall within this category was seconded by Dr. Carlos Torres-Verdin. Passed by majority vote.

A motion made by Adam Haecker to reinstate the Tulsa Chapter was seconded by Doug Patterson. All approved, and the motion passed.

A motion made by Adam Haecker to vote on the Outstanding Professional Chapter Award was seconded by Dr. Jesus Salazar. Results of the vote"
Chapters recommended for the award and vote tallies:
Six board members selected London Chapter
Five board members selected Boston Chapter
This motion passed by majority vote to Candidate London Chapter.

A motion made by Adam Haecker to vote on the Outstanding Student Chapter Award was seconded by Doug Patterson. Results of the vote follow.
Chapters recommended for the award and vote tallies:
Two board members selected Texas Tech University
Two board members selected University of Oklahoma
Four board members select University of Texas
Three board members (abstained or did not participate)
This motion passed by majority vote to Candidate University of Texas.

Action Item: Jim Hemingway, contact Katerina Yared to make suggestions and discuss ideas for the new "Nuggets of Wisdom"

Action Item: Sharon Johnson send out a survey to the membership for the *Petrophysics* Journal and *SPWLA Today* Newsletter. Collect questions for the survey from Dr. Carlos Torres-Verdin.

Meeting adjourned 11:45 a.m.

Respectively Submitted by
Sharon Johnson
Executive Director

SPWLA 2019–2020 BOARD OF DIRECTORS

We hope to see you at the 2019 Annual Symposium Business Luncheon in the Woodlands,Texas, Monday, June 17 to **welcome our new and continuing Board members and to thank to our outgoing Board members!!**

PRESIDENT
Jesús M. Salazar - Marathon Oil

PRESIDENT–ELECT
James "Jim" Hemingway - Consultant

VICE PRESIDENT – TECHNOLOGY
Michael O'Keefe - Schlumberger

VICE PRESIDENT – EDUCATION
Katerina Yared - SM Energy

VICE PRESIDENT – FINANCE, SECRETARY AND ADMIN
Doug Patterson - Baker Hughes, a GE company

VICE PRESIDENT – PUBLICATIONS
Tom Neville - Asia-Pacific Formation Evaluation Services

VICE PRESIDENT – INFORMATION TECHNOLOGY
Lin Liang - Schlumberger

REGIONAL DIRECTORS

North America, POSITION 1 (2 year 2018–2020)
Adam Haecker - Continental Resources

North America, POSITION 2 (2 year 2019–2021)
Kelly Skuce - Obsidian Energy

Latin America (2 year 2018–2020)
Nadege S. Bize Forest - Schlumberger

Europe (2 year 2019-2021)
Craig Lindsay - Consultant

Middle East/ Africa/ India (2 year 2018–2020)
Shouxaing "Mark" Ma - Saudi Aramco - Dhahran, Saudi Arabia

Asia and Australia (2 year 2019–2021)
Jennifer Market – Lloyd's Register

Carlos Torres-Verdín
2018–19 VP Publications
cverdin@mail.utexas.edu

ONE SPWLA

All good and enjoyable things usually come to an end: Sadly so, this is my last issue of *SPWLA Today* as VP Publications and Editor but, happily, surely not the last one as independent columnist!

When I conceived of the idea of *SPWLA Today* and proposed it to the SPWLA Board nearly two years ago, I was not sure about how attractive, interesting, and self-sustaining the new periodical publication would be to our esteemed membership. We would be splitting content from *Petrophysics* and some of my colleagues were not happy about it; it seemed a bold move that could antagonize our membership during not the best time in the petroleum industry ("why fix what's not broken?" was the recurrent adage). My apprehensions are all but abetted now. Judging by the vibrant content of this very issue, for instance, it just seems senseless in retrospect that we once harbored doubts about the success of *SPWLA Today*. It has now a life of its own!

But we are done yet. We need to make sure that *SPWLA Today* continues its *transformative* path to *communicate, inform, share,* and *expand*, doing it with a flexible and adjustable format. What I have witnessed during the last seven issues of *SPWLA Today* is that our professional society has a very unique, deep, and varied fabric across the world. The formal and rigorous technical articles included in *Petrophysics* are not able to capture all the overtones and counterpoints of that fabric. And rather than solely functioning as an informative newsletter, my impression is that *SPWLA Today* is becoming a catalyst of that unique fabric; constructive biological co-evolution appears to be an apt paradigm to explain this fortunate occurrence.

An added bonus to my work with *SPWLA Today* has been the opportunity to interact with multiple column authors and contributors across the world who, like me, enjoy and treasure the numerous labyrinths of our professional society. I thank all of them for their support and enthusiasm, and for sharing with all of us their passion for formation evaluation. I also want to thank my colleague, Stephen Prensky, for working with me as managing editor of *SPWLA Today*, making sure that all columns, articles, and contributions were well written and composed. It has been a great experience to work alongside him during the last two years despite some normal disagreements and differences in point of view that easily eroded away. A note of special gratitude goes to our efficient SPWLA staff, Ms. Sharon Johnson, and Ms. Stephanie Turner, whose help was fundamental to collating and assembling informative segments about SPWLA events. I would also like to thank the ever-so motivated champions of the Young Professionals Network for *The Bridge* section, which was always replete with passion, culture, and inspiration; you guys rock!

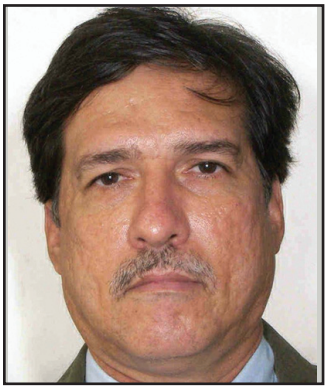
I regret that only a handful of SPWLA members sent us comments for change and/or improvement along the way. May this situation be interpreted as implicit satisfaction and not as passive lack of interest in the future of our fledging periodical publication. Please rest assured that we did the utmost to accommodate every comment and suggestion received. As an educator and researcher myself, I hope that *SPWLA Today* was able to bring bling and shine to students and young professionals, thereby enticing them to spend their professional careers in the fabulous world of formation evaluation, to eventually become the heart, torch, and soul of the SPWLA.

My personal wish is that *SPWLA Today* continues to widely and equitably represent all sectors of our professional society, reaching across gender, race, age, and geographical locations, serving students and professionals alike. In summary, bringing about ONE SPWLA for all: now and forever, to lay out the rich fabric and tapestry that makes us such a unique society!

Lastly, with the recent election of Mr. Tom Neville as upcoming 2019–2020 VP Publications and Editor of *Petrophysics* and *SPWLA Today*, I am certain that the future of our publications will be bright. Tom unequivocally brings new ideas and energy to make SPWLA even better. Changes are good and I wholeheartedly pass the baton to him looking forward to working as a team during the transition period.

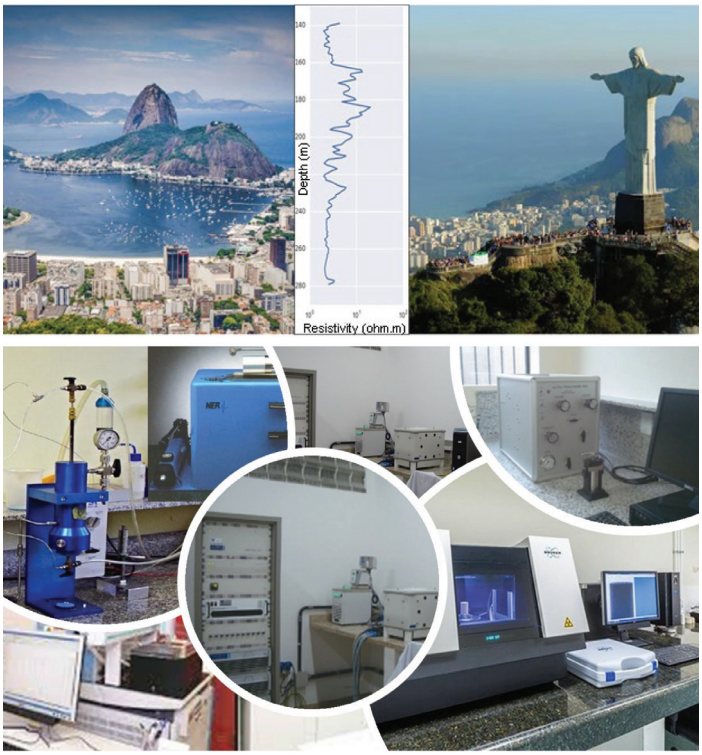
Thanks for your continued support. It has been my honor and pleasure serving as your editor and member of the SPWLA Board. It was a ride of a lifetime!

Sincerely,
Carlos Torres-Verdín



Professor Abel Carrasquilla
UENF/CCT/LENEP, Macaé – RJ - Brazil

We can say that petrophysics and formation evaluation in Brazil began with Carlos Dias, when he finished his doctoral thesis at the University of California, Berkeley, USA. Upon returning to Brazil in 1968, he settled in Salvador-BA, working at the Federal University of Bahia, where he founded the Center of Studies in Geology and Geophysics. In 1986, he moved to the Federal University of Para, where he started the Nucleus of Studies in Petroleum Geophysics. In 1993, he went to Northern Rio de Janeiro State University, where he created Laboratory of Engineering and Exploration of Petroleum. In all these places, he installed courses and research lines, in geophysics, petrophysics and, formation evaluation. He is, currently, retired but continues to work in theoretical and experimental petrophysics.



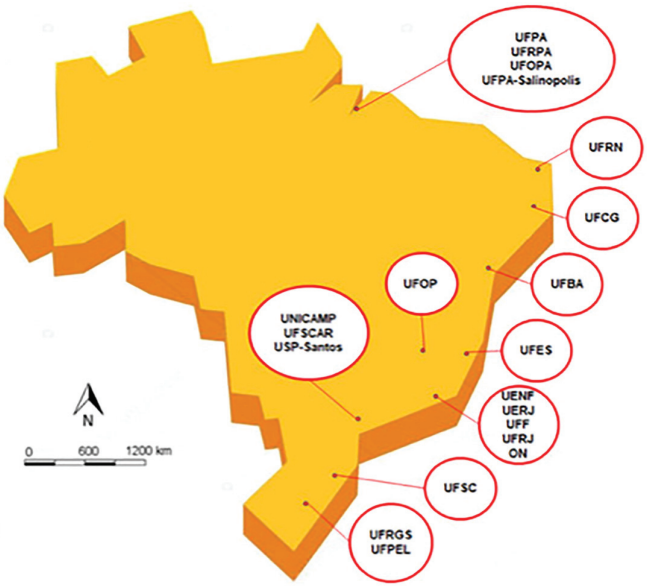


Fig. 1—Geographical location of Brazil's universities.

Since the 1970s, there have been professors working in petrophysics and formation evaluation in Federal University of Para, such as William Sauck (University of West Michigan), José Luiz and Brigida Rocha. But it is worth mentioning that in 1986 Professor Dias instituted a specific course in petrophysics and formation evaluation at that university: the Nucleus of Studies in Petroleum Geophysics. This course brought invited professors from within the university, from other universities, as well as from industry, such as Stefan Luthi (Schlumberger), Allen Howard (State University Utah), Michael Lovell (University of Leicester), John Lovell (Schlumberger), Hilton Evans (Marathon Oil Company), James Hallenburgh (Consultant), Dirceu Abrahão (Petrobras), Geraldo Nery (Petrobras), Luiz Rijo, Om Verma and João da Silva (Federal University of Para) (Fig. 2).

Fig. 2—Professor Stefan Luthi, teaching a course on characterization of carbonates (2012), with students from Petrobras and different Brazilian universities at the Northern Rio de Janeiro State University in Macaé- RJ-Brazil.

Thanks to these initiatives, there are professors and researchers in petrophysics and formation evaluation in many Brazilian Universities. For example: Olivar Lima and Geraldo Nery at Federal University of Bahia; Andre Andrade, Klaus Cozolino and Brigida Rocha at Federal University of Para; Paulo Carvalho at Rural Federal University of Para; Carlos Guerra at Federal University of West Para; Abel Carrasquilla at Northern Rio de Janeiro State University; Agnelo Soares at Federal University of Campina Grande; and Paulo Salvadoretti at Federal University of Rio Grande do Sul. A second generation was formed for these professors, with Carolina Barros at Federal University of Para; Marco Ceia and Roseane Missagia at Northern Rio de Janeiro State University; Alfredo Carrasco at Fluminense Federal University; Marilea Ribeiro at Federal University of Para-Salinopolis; and Carlos da Silva at Federal University of Espirito Santo.

Other initiatives in petrophysics and formation evaluation, independent of these original ones, have appeared in other Brazilian universities and research institutes such as: Campinas State University with Osvair Trevisan and Alexandre Vidal; National Observatory with Geovanni Stael; Fluminense Federal University with Rodrigo Azeredo; Rio de Janeiro Federal University with Jadir da Silva e Leonardo Borghi; Ouro Preto Federal University with Maria Barbosa; Sao Paulo University-Santos with Carina Ulsen and colleagues; UERJ with Marcus Ade; and Celso Fernandes at Federal University of Santa Catarina.

The undergraduate and postgraduate courses in the areas of petrophysics and formation evaluation at Brazilian institutions have developed over the years and have reached maturity. These courses follow international standards regarding the concepts, methods, level of the teaching staff, etc. They are controlled by the Ministry of Education and the Coordination for the Improvement of Higher Education Personnel (CAPES). The international cooperation in these areas has grown a lot recently and is continually being stimulated. Cooperation covenants and joint projects exist with many internationally recognized institutions, such as Heriot-Watt University, University of Texas at Houston, University of Montpellier, Delft University, University of Manchester, University of Novosibirsk, University of Calgary, University of Perth, among others.

At many universities there are only undergraduate courses in geology, geophysics or petroleum engineering, while other universities may have only postgraduate courses and/or the full range of undergraduate, master's and doctoral degrees. The duration of the courses, in all cases, meets international average, i.e., five years to bachelors in geology and geophysics and, petroleum engineering. Two years for the master's degree and four years for the doctorate. The courses include, in teaching and research, basic disciplines of engineering (physics, chemistry, calculus, etc.), geosciences (geology, geochemistry and geophysics), petrophysics (experimental petrophysics and physical properties of rocks) and evaluation of formations (well logging in open and cased holes, formation tests and mud logging). Foreign students, mainly from Latin America and Africa, participate in the courses. The post-doctoral degree is an official activity and, happens in many institutions.

The undergraduate students at these institutions attend the disciplines of petrophysics and formation evaluation. The graduate students take these disciplines and complete their theses and dissertations. A large part of the results achieved in the work of these students is presented at international conferences, such as the Society of Explorations Geophysicists, European Association Engineers and Geoscientists, Society

of Petroleum Engineers, Society of Petrophysicists and Well Log Analysts, among others. The most important results are published in national and international scientific journals of high impact factor in the areas of petrophysics and formation evaluation, such as *Geophysics, Journal of Applied Geophysics, Geophysical Prospecting, Marine and Petroleum Geology, Journal of Petroleum Science and Engineering, Brazilian Journal of Geology, Brazilian Journal of Geophysics, Journal of Sedimentary Research*, among others.

The Nucleus of Studies in Petroleum Geophysics course at Federal University of Para also trained many Petrobras technicians, including Jose Bucheb, Eduardo Ramos, Domingos Negrao, Alberto Laranjeira, Ajay Chaba, Nuno Couto, Jose Marques and Fernando Pantuzzo. Other professionals who graduated in this course, such as Ajay Chaba, Carlos Goncalves, Sergio Brochado, Alvaro Buoro, Albano Bastos, among others went to work for operating and service companies, including Petrobras, Shell, Schlumberger, Galp, Total, IBM, BG, OGX, and Hydrolog.

Petrobras, on the other hand, created the Corporate University in 1955, and its new structure in 2005, which provided in-house training and the continuing education for its employees. This university was created from the understanding that the development of skills is essential for the success of the company. The Corporate University, in partnership with Brazilian Universities, develops skills needed by the petroleum industry, up to the implementation of master's and doctoral programs. It is composed of six schools, including the Science and Technology of Exploration and Production, which includes petrophysics and formation evaluation. Many professionals currently work or have previously worked, in this area, within the company, including Carlos Beneduzi, Apoena Rossi, Nelson Pereira Jr., Carlos de Andre, Eduardo Oliveira, Paulo Netto, Paulo Denicol, Vinicius Machado, Fernando Maia, Maury Correia, among others (Fig. 3).

(a) (b)

Fig. 3—(a) Facilities of the Leopoldo Miguez de Mello Petrobras Research Center, and (b) Petrobras Corporate University, Rio de Janeiro, Brazil (modified from http://www.petrobras.com.br/).

Prior to 1997, funding for education and research at Brazilian universities took place through government agencies and/or Petrobras. As of that year, the National Agency of Petroleum, Natural Gas and Biofuels (ANP) was established to encourage research in the O&G sector via a new funding mechanism: assessing a percentage the production profits from oil fields. For high productivity oilfields, this value is equivalent to 1% of gross production profits. The amounts thus generated will be invested in research, development and innovative projects that can be carried out by the oil company itself, by Brazilian companies or by accredited institutions throughout the country. This greatly increased the amount of resources invested in institutes and universities, which resulted in the construction of new teaching and research facilities, including laboratories (Figs. 4 and 5).

Fig. 4—New facilities for teaching activities and for research laboratories (modified from http://www.anp.gov.br/).

Fig. 5—New research laboratories (modified from http://www.anp.gov.br/).

Thus, in the last 50 years, Brazil has found its own way in education and research in petrophysics and formation evaluation. Hundreds of professionals and specialists in geology, petroleum engineering and geophysics were developed. Currently, most institutes and universities that have undergraduate and postgraduate courses, teach subjects in petrophysics and formation evaluation, including the universities mentioned above, in addition other examples, such as Federal University of Rio Grande do Norte, Federal University of Pelotas, University of Sao Paulo-Sao Carlos, among others (Fig. 6). After graduation, most students will work in the oil and gas, mining, or environment industries (Fig. 7).

Fig. 6—Professionals of the Society of Petroleum Engineers and students participating in the 2013 South America and Caribbean paper-contest for undergraduate, master's and doctorate students (modified from http://www.lenep.uenf.br).

Fig. 7—Petroleum Engineering students from Northern Rio de Janeiro State University participate in several technical visits to oil companies (modified from http://www.lenep.uenf.br).

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Empowering Formation Evaluation, One Project at a Time!

Carlos Torres-Verdín, Ph.D., Professor

My professional experience in industry and academia abounds with examples of how the discipline of formation evaluation is in general undervalued, underused, and underpaid by the petroleum industry; too many unders and not enough overs… But why? Is this our predestined role or is the role in which we have molded ourselves into? Why does the petroleum industry predominantly think of us that way? How can we motivate intelligent, energetic, and goal-oriented young minds to pursue a challenging career in formation evaluation despite such somewhat adverse professional perceptions?

Reservoir and production engineers have traditionally been in the driver's seat of the petroleum industry just because they are the closest to the endpoint of the upstream added-value chain; they regularly receive the largest salaries and bonuses. All too often, I have seen how young formation evaluation specialists decide to move into the reservoir engineering camp after a few years of experience in operating companies and with the same aspiration in mind: "… I want to be closer to the center of the action…"

The truth is that formation evaluation lies within a very unique and privileged technical niche: it combines geological, geophysical, petrophysical, and reservoir engineering knowledge like nowhere else in the exploration and development of subsurface resources, serving as the centerpiece that "glues" the other components together. This is why we love what we do and spend so much time challenging ourselves with brain-teasing problems in geology, physics, instrumentation, signal processing, and fluid flow in porous media; it's like solving a giant and multidimensional sudoku puzzle! Furthermore, the largest, spatially densest, and most diverse measurements are invariable collected in wells. That immediately places us in a very important abode concerning the value of information. One would expect royal treatment just because of that, right? This sounds very quixotic but why does it not seem to have a substantial effect on the professional reward system of today's world?

Most often, the industry identifies well-log analysts, petrophysicists, and formation evaluation practitioners as some sort of highly specialized group that takes mud logs, well logs, and core measurements to generate continuous plots along well trajectories of dominant minerals, porosity, fluid types, fluid saturation, and permeability ("… they are the folks that know how Archie's equation works…" is frequently said to define us). I have heard similar comments in geosciences and petroleum engineering academic circles. Such misperception then continues with the assumption that calculations performed by formation evaluation specialists are primarily used to estimate reserves and, on occasion, to detect and rank fluid production intervals. The calculations and interpretations performed by formation evaluation specialists, unfortunately, seldom make it to the ranks of reservoir/production engineers because they are either too specialized, too detailed, or too difficult to digest in the fast clip of the production world. Of course, there are excellent examples of the opposite; one must not fall into the trap of blanket statements and false generalizations. Let us just state that there is definitely a prevalent trend there.

The information and interpretations produced by formation evaluation specialists are also of great interest to geophysicists, drillers, and completion engineers but are often not used to their full potential. Why?

Service companies continue to develop new, better, more reliable, more accurate, and sometimes less expensive borehole measurements but they seem to struggle to convince reservoir engineers of the worth of their measurements in the added-value chain of an operating company. The question that is often posed is: How will the investment made in a new (perhaps "boutique") borehole measurement help to reduce lifting costs and improve ultimate recovery? Arguments can become very heated when trying to convince drillers to acquire more measurements than just gamma-ray logs while drilling highly-deviated wells. More recently, formation evaluation specialists have placed themselves in the center of gravity of drilling and geomechanics by helping to geosteer wells with sophisticated deep-sensing measurements, or by turning new-generation sonic logs into rock mechanical properties that are extremely valuable for hydrofracturing operations. In these latter arenas we are slowly but surely becoming more important to folks who control the biggest budgets!

Enough of complaining and whining about unfair discipline treatment! What should we do? More than ever, our profession should intimately concern itself with fluid production. Traditionally, the role of formation evaluation has been delegated to geologists and former logging engineers. This has pros and cons, just like anything else; during my professional career I have worked with extraordinary geologists from whom I have learned very useful and mind-changing concepts. Geologists are not afraid of working with complex problems and are quick to think in three dimensions. On the other hand, former logging engineers understand very well when measurements are good, bad, or marginal; they comprehend deeply the physics behind the instruments and their measurements, are quick to grasp the importance of borehole/drilling environmental effects on well logs, and are dexterous with interpretation software. But we need to quickly translate those geological concepts and measurements into engineering descriptions of single and multiphase fluid flow; this is what most geologists and former logging engineers are

not comfortable doing. Petroleum engineers do it on a daily basis but many of them overlook the complex geological controls of multiphase fluid flow that we frequently observe in well logs.

During the last 20 years I have interacted closely with some of the brightest reservoir engineers on the planet. In so doing, I have grown to appreciate the great emphasis they place on thermodynamics, fluid chemistry, and immiscible/miscible fluid flow in porous media to select specific production procedures from their vast arsenal of enhanced recovery methods. But I have also observed that their selection of procedures often does not take into account the high degree of spatial variability of rock properties that we customarily infer from well logs or borehole images. In fact, even the most sophisticated, contemporary reservoir simulation algorithms are unable to capture the great variability in rocks that we are accustomed to seeing in the formation evaluation world; their upscaling techniques often serve as mere palliatives to assimilate the effects of rock complexity on fluid flow. This interesting disconnect is what places us in the center of the lofty action. Formation-tester specialists know it all too well. We need to be able to understand the basics of capillary pressure, relative permeability, immiscible/miscible fluid displacement, pressure compartmentalization, etc., to talk the same language of reservoir engineers.

Fig. 1—Example of a sandstone-shale laminated sedimentary sequence that is typically well quantified with well logs but that presents significant technical challenges to reservoir engineers when designing primary or secondary hydrocarbon recovery methods, especially where laminations are the most pervasive. Numerical simulations performed by reservoir engineers to forecast fluid production and pressure depletion in this type of rock systems require multiphase upscaling procedures that are not currently reliable [Tide Influenced Delta, Frewins Castle Sandstone, Belle Frourche Member, Frontier Formation, Cretaceous (Cenomanian), Tisdale Mountain Anticline, Wyoming; Photograph by Rob Wellner].

Many reservoir engineers are not accustomed to taking into account rapid spatial variations in rock properties to adapt their EOR processes. If they were willing to work closely with petrophysicists they could adapt and refine their procedures to be rock-class (flow-unit) dependent, for instance, hence more effective and efficient. A relevant example is the fact that EOR techniques are barely understood in the case of shale-sandstone laminated systems (see Fig. 1), and less so in the case of spatially complex carbonate systems. Formation evaluation specialists understand very well that the petrophysical properties of rocks can be extremely variable within short depth intervals. It is a pleonastic truth to them that EOR processes need to be adapted to

account for rock variability; one size does not fill all!

The organic shale revolution and, in general, the world of unconventional hydrocarbon reservoirs, have endowed added importance to formation evaluation. For instance, I have heard some petroleum engineers erroneously say that efficient hydraulic fracturing is more important than accurately assessing TOC in organic mudrocks. I have also run into geophysicists who still think that neutron logs are continuous measurements of total shale porosity. These are just a few reasons why the industry needs us more than ever to make robust investment decisions in a challenging and uncertain financial and operational landscape.

So what can we do to empower formation evaluation in today's workplace?
Here I go with some suggestions:

(1) Understand the petroleum system at hand. Understand the role played by geology and geochemistry in constraining thermodynamic fluid properties, pressure seals, compartments, structural and stratigraphic traps, etc.
(2) Understand the role played by geophysical measurements in detecting and quantifying important features of the petroleum system, before, during, and after fluid production.
(3) Understand the dominant storage and flow controls within a reservoir.
(4) Understand what reservoir/production engineers need and understand whether we have enough and adequate measurements to go beyond the assessment of reserves. Understand the reservoir production mechanisms and flow controls (flow units). Understand whether the reservoir is to be produced by primary or secondary means or a combination of both. Do not spend too much time on something that will ultimately not be used in the added-value chain. Speak the language of reservoir engineers, geologists, drillers, and geophysicists. Alert reservoir engineers of extraordinary rock complexities evidenced by well logs and core samples. We can turn ourselves into much better petrophysicists if we learn and question the elements of reservoir engineering. And we don't need to be pretentious about it.
(5) Do not oversell the value of well logs (especially the so-called "boutique" well logs) or core measurements; make sure that the information to be obtained from core measurements will justify their cost regardless of technical, size, and resolution limitations. Coring and analyzing complex rock segments is seldom a bad idea.
(6) Maximize the potential of formation-tester measurements to detect and quantify crucial reservoir engineering properties. There is also a wealth of reservoir-engineering data in drillstem tests and production logging measurements that we need not overlook.
(7) Quantify rock-adaptive primary or secondary fluid production processes; i.e., the very concept of flow units. Understand that the spatial-temporal fluid flow mechanisms are usually constrained by large-scale reservoir features, baffles, constrictions, and seals. Do not overstate the flow mechanisms solely inferred along the well trajectory.
(8) Focus on the big production picture and make sure that we are turning out calculations and interpretations that quantify production potential, not only in-place reserves, and help to define more effective and efficient drilling and well completion strategies.

In summary, we want to be the harbingers of production-oriented petrophysics, or better yet, *X-Treme Production Oriented Formation Evaluation*!

There is no need any more to metamorphose ourselves into reservoir engineers in order to move up in the ladder of professional recognition; we just need to make sure that formation evaluation is given its proper worth by reservoir engineers via us reaching across the aisle. This attitude and emphasis also need to be part of the formal academic education in geosciences departments throughout the world. By promoting the fluid production facets of formation evaluation we will forestall a new, much needed chapter for reservoir engineering where *X-Treme* rock complexity will be commonplace when prognosing fluid production and pressure depletion. It will be another win-win situation for all of us who care about doing things better; the rewards will be immense everywhere!

Sincerely,
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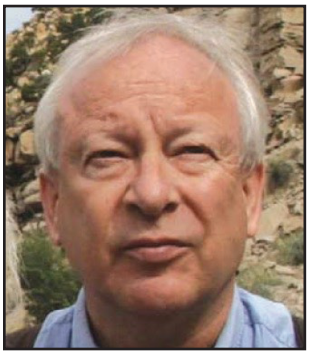
Petrophysics, Rock Complexity and Fluid Flow



Stefan M. Luthi
Professor Emeritus,
Delft University of Technology,
The Netherlands
Past Schlumberger Senior
Technical Advisor

My Dear friends in the Petrophysics Community,

In this second column I have been invited by SPWLA's VP Publications to share my thoughts on how petrophysics relates to fluid flow—a relationship that obviously has to involve serious considerations on rock complexity. Fluid flow is, of course, a relatively vague—or to phrase it more positively—broad topic, as in this particular case, it concerns porous media with a vast range of properties and scales that may range from millimeters to many kilometers. On top of that, most, if not all reservoirs are heterogeneous and their rocks anisotropic.

In view of these complexities some may argue that this field is better left to physicists, reservoir engineers and perhaps geologists, but I posit that it is certainly worthwhile exploring the possible contributions that petrophysicists can inject. After all, the most detailed and continuous information on a reservoir comes from petrophysical data and the interpretations thereof. I say this as a geologist well aware of the fact that cores provide also very detailed information, but knowing that in most wells cores are not usually taken, and cuttings have their own drawbacks in terms of depth accuracy and alterations caused by the drilling process.

Therefore, I invite you to consider with me two examples of how petrophysics can be related to fluid flow. One will be small-scale and near-wellbore, and the other one large-scale and reservoir-wide. What we leave out here is downhole wireline testing, which is a field that is indeed best left to reservoir engineers. But these days petrophysicists have a powerful set of downhole measurements that provide very useful information on rock complexity, and notably the pore network, which is crucial for the ability of fluids to flow through the rocks, a property—as everybody knows—termed permeability. I refer of course to nuclear magnetic resonance (NMR) measurements. In my view it is hard to overstate the breakthrough that these measurements represent in understanding rocks in general and in particular, their pore volumes, types and connectivities.

When considering pore types, one realizes that sandstones, which represent a large percentage of the global oil and gas reservoirs, have essentially one dominant pore type, and that is the intergranular one, i.e., the space between the sand grains (I admit I simplify here but try to emphasize the main line). This space gets reduced as sand is compacted and cemented into sandstone during burial: Not only get the pores reduced, but also the pore throats connecting them, and these are crucial for the ability for fluids to flow through the rock. Permeability has the dimension of length squared, and, in a simplified view, the smaller the cross-section of the pore throats, therefore, the lower the permeability. This means that, for many reservoirs, the relationship between porosity and permeability is relatively straightforward in sandstones, as has been documented in a significant number of publications. Very often, therefore, one can establish a relational equation between these two parameters, with permeability derived, for example, from core plugs, that holds quite well in a given reservoir.

Things get a lot muddier in carbonates because there is a much wider variety of pore types. Rather than describing them all I refer here to a well-known landmark paper (Choquette and Pray, 1970) on this topic. There are highly porous oomoldic dolomites that have very low permeabilities because the pores are very poorly connected. One the other hand there are grainstone limestones that, for the same porosity, have permeabilities many orders of magnitude larger. And fractured carbonates with much lower porosities can have even higher permeabilities than those. All to say that the relationships between porosities and permeabilities is very complex in carbonates and highly dependent on the pore types. A few years ago (the way it feels) two colleagues and I undertook a study to address this issue (Anselmetti et al., 1998). We made a collection of "end-member" carbonates, with each sample being dominated by one pore type, or, at the most, two. We measured the porosity, the pore geometries and sizes with digital image analyses at a wide range of scales, and we measured the permeabilities on core plugs. We then examined which pore parameters influenced the permeabilities the most, and for this we used artificial neural networks. One result of significance was that if one knows the total porosity, the amount of microporosity and the average macropore shape, one can quite accurately determine the permeability of a sample. Two of these parameters can be derived from NMR measurements, and the third one (the macropore shape) may be approximated from other measurements, such as the sonic logs, or from general geological knowledge. But for low permeabilities, it turns out that a knowledge of the total porosity and the microporosity is sufficient for a good prediction of permeability, while for higher permeabilities, the total porosity and the pore shape is needed for a good prediction of permeability. Is this good news? Well, some readers may argue that NMR tools by way of the T_2 metric, measure the pore size, but this is only true if there is only one pore type with approximately the same geometric shape. What it really measures is the surface-to-volume ratio, and that is pore-shape dependent. An intergranular pore with

many branches leading via pore throats to the neighboring pores has a much larger surface than a spherical oomoldic pore of the same size. Luckily, micropores usually do not differ much in their shapes, so if one is dealing with a carbonate rock that has some microporosity and macropores of one dominant type, then the above approach to estimate permeability seems reasonable, and there are empirical equations along this line that have been proposed. In the presence of more complex pore systems, however, more research may be needed. In sandstones, with usually one dominant pore type, the established empirical approaches seem justified. For the case of more than one pore fluid - glossed over above—there has been some exciting work in the recent past that involves the analysis of diffusion and spin relaxation time distributions (Hürlimann et al. 2002).

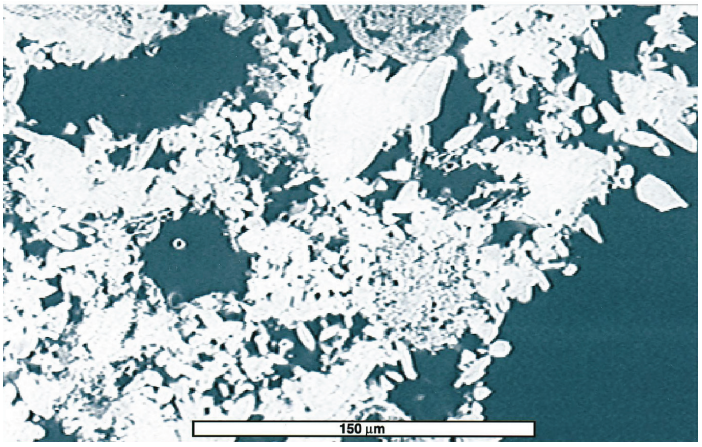


Fig. 1—Environmental SEM image of a carbonate with micropores as well as intergranular and moldic pores (Choquette and Pray, 1970).

Let us now proceed to a larger scale and assume that we have successfully determined the most relevant petrophysical properties in two wells and grouped them into "facies", each with more or less the same properties, or property ranges. The following is an example I have shamelessly taken from Schlumberger's *Oilfield Review*, and I have discussed it over many years with the students attending my courses, always resulting in lively exchanges. The space between these two hypothetical wells has been filled using two different stochastic distributions, or, in geological terms, two different sedimentological models. In Case A, the lateral correlation lengths of all five facies are quite large, while in Case B, they are much shorter but the vertical stacking is relatively more pronounced, i.e., it is not a miniaturized version of Case A. It is not very important which facies has which properties, we just assume they are different for the five facies types. There are also permeability (shale) barriers indicated by horizontal black lines, meaning that there will not be any vertical flow across them. These are clearly two quite different reservoir models, but the wells at both ends of the cross-sections are identical. After assigning petrophysical properties and oil as well as water saturations to the different facies types, one pore volume (of the total cross section) of water is then injected from the left well to the producer at the right end. The question then is in which scenario is more oil produced in the second well. Have a good look at it and try to figure it out! I will give the answer on a separate page of this issue together with some comments.

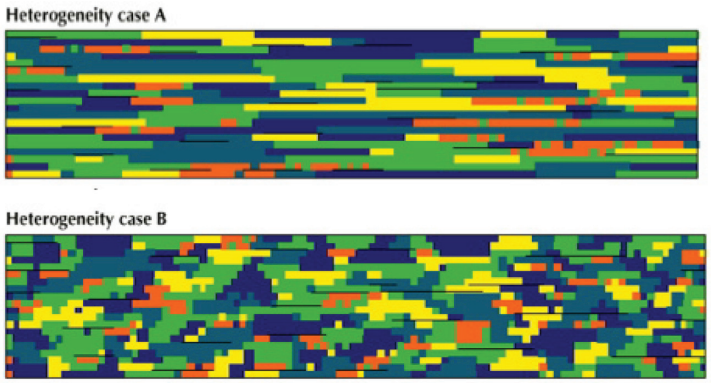


Fig. 2—The two 2D hypothetical reservoir models.

The reason why I show this example here to a (mostly) petrophysical readership may be puzzling to some, but I think I have a good reason for doing this. As I stated in my previous column, the vertical stacking of rock types in a well is not random, it follows certain rules, mostly on a sequence stratigraphic basis. This, in turn, has implications on the lateral extent of these layers, and their lateral juxtapositions (something known as "Walther's Law"). Therefore, if the petrophysicists do their work well and, together with their geologist friends, come up with a robust interpretation of the well data, the lateral extrapolation further away from the well may be much easier to make. There is of course a plethora of software that is available for these tasks, but going back to the basics of petrophysics and geology—in other words thinking rather than clicking on screen options—is in my opinion, always very useful.

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It's About Time! Engaging Petrophysicists to Deliver Seismic Petrophysics

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PROLOGUE

Humans are prone to track the inevitable march of time, in both personal and professional lives, by observing significant milestones. These milestones can be specific events, certain years, or the turn of a new decade. In my own case, I embarked on a new (fourth) decade of my professional career during the second half of 2018, and so I have been engaged in a certain amount of introspection and self-reflection. More recently, I was recognized as a "Rock Physics Influencer (RPI)" by the International Association of Rock Physicists (Kittridge, 2019), which gave me the opportunity to pause and ruminate on both my own path in "rock physics" (Seismic Petrophysics), and to speculate about current issues and remaining challenges. So when I was contacted by Dr. Torres-Verdin and asked to consider a submittal for the *SPWLA Today* Newsletter, on that same general subject matter, it was rather easy to respond with an enthusiastic "Yes".

What follows here is hopefully a better written (and illustrated with select figure content) version of some of the discussion points included in the RPI profile. I hope that by including this in *SPWLA Today* the content will find a way to more desks and (digital) file folders of petrophysicists, who may then be further enabled or encouraged to take up some of the practices discussed below. As such, I will write in a deliberate manner where the comments are intended for the petrophysical community, but could certainly also be used by a (QI) geophysicist interested in learning more about where his/her well data and model(s) come from. The list of references included herein should also serve as a listing of the essential papers for someone wanting to know more, access some select measured data, and get started in Seismic Petrophysics. All data and models shown here are in the public domain, and the examples are easy to reproduce with your toolkit of choice.

ON THE ORIGINS OF SEISMIC PETROPHYSICS

To begin, a quote from Blangy (1992), on the role of "petrophysics" in seismic (lithologic) interpretation:
"The seismic amplitude information is rich yet goes mostly unused. … and I believe that petrophysics appears to have been the **'weak link' in quantitative seismic lithologic interpretation**." Blangy (1992) emphasis from original

The first documented formal definition of "seismic petrophysics" is from Pennington (1997). While it is not clear or known whether Pennington was aware of or responding to the view expressed in Blangy (1992), his definition and paper was the direct result of the 1996 SEG Development and Production (D&P) Forum. The D&P Forum continues today as an annual SEG workshop, and is seen as the "reservoir geophysics" workshop.

" …The purposeful application of rock physics theory, as calibrated by laboratory ***and*** well measurements, to the interpretation of seismic data." Pennington (1997) (emphasis added).

Some key points made by Pennington deserve mention, as subsequent work, largely case studies, further develop workflows and ideas suggested in the 1997 paper.

- We need to locally calibrate seismic response to observations made in nearby wells, or to core taken from those wells.
- Interpretation of well data, particularly acoustic (sonic) data, has improved, given significant advances in sonic log acquisition and processing. Note: for context, remember the time this was written (1997) and the recent advances with full waveform sonic logging and the downhole acquisition of waveform data for reliable picking of both P- and S-wave velocities.
- Use of calibrated shear velocities in the Gassmann equation for fluid substitution should yield a much more reliable estimate for reservoir properties than empirical trends observed in wells in other areas or in laboratory data.
- Laboratory investigations are extremely important in understanding the physics of elastic-wave propagation in specific rocks.
- Three hurdles to the (more) widespread use of seismic petrophysics:
  - Infrequent use of proper wellbore measurements;
  - Lack of understanding of rock physics theories at an appropriate level; and
  - Shortage of clear case histories to follow.

Towards the final points made by Pennington (1997) on increasing the use of seismic petrophysics, I would submit that clear progress has been made on both improving the use of proper wellbore measurements (Kittridge, 2004; Smith, 2011) and presentation of documented case histories (Smith, 2001; Kittridge, 2008) where seismic petrophysics workflow(s) are developed and applied to real data (lab- and well-derived). Of course, the practicing reservoir petrophysicist is already highly skilled and routinely applying core-log calibration methods to traditional (reservoir) evaluation products (net-to-gross, porosity, water saturation, and reservoir mineralogy).

Many are surprised to realize that rock physics has a long tradition of using core-measured acoustic properties (P- and S-wave velocity measurements)—in much the same way as a petrophysicist—to bring calibration data to the rock physics domain. This document aims to further awareness on the first two 'hurdle's mentioned above, with the implicit intent that more petrophysicists might be developed into practicing Seismic Petrophysicists.

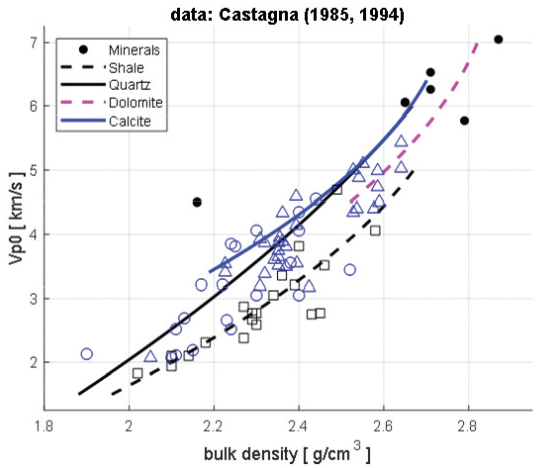
CORE COMPETENCIES IN SEISMIC PETROPHYSICS

The petrophysicist has a very clear role to play in the delivery and realization of the integration implied by Pennington's (1997) definition, as the petrophysicist is the designer and primary interpreter of the measurements necessary for any rock physics model development. Absent the active participation of a petrophysicist, we too often find essential data QC omitted and necessary formation evaluation detail(s) overlooked. This can lead to well-based rock physics inputs (density, velocity, porosity, and saturation) which are limited or misleading. Workflows described by Kittridge, et al. (2004) and Smith (2011) describe sequential, but always iterative, work streams that emphasize the important role played by critical (early) evaluation of well data and purposeful integration of robust reservoir petrophysics inputs. In the following segments, I will highlight three absolutely essential skills required to deliver Seismic Petrophysics and realize the impact of truly integrated interpretation enabling geophysical and geomechanical applications.

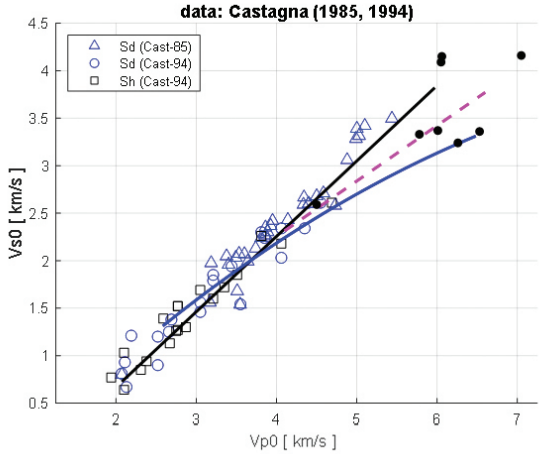
Integration and Wellbore Data QC: Density, and Velocity. The key deliverables for the geophysicist interpreting seismic data are bulk density, and both compressional-wave (V_p) and shear-wave (V_s) velocity. The seismic experiment is driven by contrasts in these values (e.g., impedance, density*velocity) at interfaces between two layers with different properties (i.e., lithology, porosity, and pore fluid(s). The geophysicist is also keenly interested in continuous logs of density and velocity, to enable synthetic seismic generation and well-to-seismic ties. This puts the burden on the (seismic) petrophysicist to spend (frequently) significant amounts of time working log data QC away from the target reservoir, and in a variety of nonreservoir lithologies. As such, careful QC of the geophysical input logs (density, velocity) is the starting point for effective Seismic Petrophysics.

The QC of those essential geophysical input data is enabled by several easy-to-implement graphical techniques, and some basic lithology-based rock physics relationships. The petrophysicist will begin with a sound understanding and appreciation for the borehole environment, possible effect(s) on log-data quality and measurement, and the fact that we generally combine data having variable vertical resolution (decreasing vertical resolution: resistivity, acoustic, and density) and depth of investigation (sonic > density). Variable borehole conditions are likely to impact pad (density) and centralized (acoustic) tools in different ways. Simple first-pass log QC (using log depth displays): logs are consistent in a given lithology; logs 'move' or trace together: P-slowness should be highly correlated to neutron porosity, with similar vertical resolution, density and P-slowness similarly correlated (though not always), and P-slowness often tracking deep resistivity. This first-pass is often an aid in focusing attention on either density or acoustic data where it may be suspect. Traditional log QC measures further help qualify good vs. questionable data: caliper, Δρ (density), semblance (acoustic slowness). It is also important to pay attention to the presence of hydrocarbon in reservoir intervals, where both density and P-slowness may be further complicated with 'soft' hydrocarbon offsets (when compared to 'wet' reservoir of similar porosity and composition). It is also important to note that P-wave sonic and density should be edited prior to the editing of S-wave sonic data.

Following this first-pass QC, further data interrogation will rely on standard rock physics templates for more detailed evaluation of well-based data. We basically have two templates, best used together (Figure 1): bulk density vs. V_p, and V_p vs. V_s. The common relationships available are for a single lithology (mineral) and in all cases presume that the measured material properties are brine-saturated. (Rock physics data and models are generally given using velocity, not acoustic slowness (interval transit time) and in units of km/s (or m/s). The use of km/s facilitates subsequent work with moduli and elastic stiffness in GPa.) In this space, the 'shale' response carries with it all the usual complications faced by the petrophysicist: mixture of chemical clay(s) and quartz, feldspar, carbonate, nature of the 'porosity', etc. We avoid difficulties with shale 'porosity' by working in bulk density directly, although that does not alleviate all potential issues (e.g., mud system, near-wellbore alteration). Data QC in this domain is further enabled by the judicious use of color on the z-axis of the plots. Data QC will benefit from using traditional borehole measurements as the z-axis: caliper, and $\Delta\rho$. For lithology calibration, an appropriate volume fraction (clay, quartz, carbonate) will be an excellent choice, but with the recognition that hydrocarbon presence (S_w) will likely also play a role in the bulk density and V_p response. The V_p-V_s template enables an initial QC of the shear velocity, but correction and further diagnostics will follow, creating a necessarily iterative workflow. Correction of anomalous data relies on application of a selected lithology-based model, and may be further supplemented with various multiple linear regression (MLR) methods (see Smith, 2011).



(a)



(b)

Fig. 1—Basic rock physics models and data, useful for the preliminary QC of well data. (a) bulk density vs. P velocity. (b) Compressional velocity vs. shear velocity. In both figures, data are open symbols, and lines are endmember lithology-based models.

Shear Log QC and Forward Modeling. An accurate shear velocity is essential input to both fluid replacement modeling and the characterization of expected AVO response at a reservoir interface (see Castagna and Smith (1994) for background on AVO methods). In the following discussion, it is presumed that a 'best' post-processed V_p and V_s dataset have been delivered from the vendor, who will likely have applied semblance or other advanced processes using original recorded waveform data. In many cases, additional work may have been done to address frequency or 'dispersion' corrections to the reported V_s data. Ultimately, the methods to QC the delivered log data or forward model missing or suspicious shear log data rely on the application of a rock physics model. These models are all lithology-dependent, and presume that the in-situ intervals are brine saturated (Castagna et al., 1985, 1993). Inspection of the V_p-V_s data in Fig. 1 suggests the following: sand (quartz) and 'shale' are minimally resolved in V_p-V_s space, particularly at lower velocities (i.e., higher porosity), and that lithology-based separation is best at low(er) porosity, particularly between quartz and carbonate minerals (dolomite, calcite). The presence of hydrocarbon will 'slow' (lower) V_p, relative to the brine-saturated lithology model reservoir trend(s), and the magnitude of the hydrocarbon offset will increase with reservoir porosity and fluid. As noted above, both lithology and S_w data serve well as z-axis discriminants in this crossplot domain.

A common model used for both shear-velocity QC and forward modeling (replacement) is that of Greenberg and Castagna (1992). This model recognizes four endmember mineral or lithology components: quartz, 'shale', dolomite, and calcite. For a single component, this model will give results consistent with endmember models described in Castagna et al. (1985, 1993) and Greenberg and Castagna (1992). The real utility of this model is in shear-velocity estimation for mixed carbonate-siliciclastic (reservoir?) intervals. In Fig. 2 we see results using data and lithology classes as reported in Fournier (2009). The lab-measured data are generally well bounded by the quartz and calcite (and upper limit V_p/V_s of 1.9) endmember relationships, and data separate consistent with measured mineralogy (XRD, point count), notably quartz and calcite. The data also provide a useful graphical reminder about the ability to resolve mineral-based differences in V_p-V_s space at low(er) velocities (higher porosity) and the nature of sample-specific variations in velocity, even on the core-plug scale.

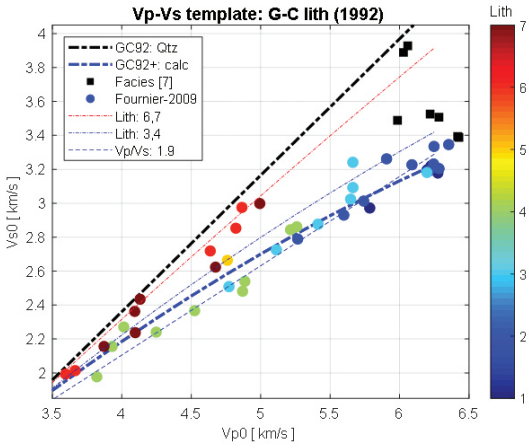


Fig. 2— V_p-V_s template, with Greenberg-Castagna endmember relationships for Quartz and Calcite. Data are core-measured results from microporous mixed carbonate-siliciclastic rocks (Fournier, 2009). Solid black squares are calculated grain properties for the seven lithology classes, based on reported mineral content. Lith Classes 3 to 5 are described as quartz-rich limestone, Class 6 is a clean sandstone, and Class 7 is sandstone with carbonate matrix. The light-blue dashed line is a fixed V_p/V_s of 1.9. Models (Greenberg-Castagna) for varying quartz and calcite volumes are given with the light-red and blue dot-dash lines.

Several final thoughts about shear velocity, before we leave this topic. In 'faster' rocks (competent, lower porosity) it is likely that a simple monopole or 'refracted' shear signal will be present, robust enough for quantitative use, and most certainly should be used to validate the dipole-derived shear velocity. When doing shear-velocity QC, pay particular attention to data at V_s values lower than ~1,500 m/s (fluid velocity), as you now require the flexural mode to determine shear speed. Data at a roughly constant V_s value with varying V_p are almost always a 'red flag' for data that require additional QC. Finally, note that more robust methods for V_s estimation, particularly in reservoir rocks, where mineralogy can be reasonably defined, take advantage of heuristic and/or theoretical models directly connected to (total) porosity to estimate dry-rock moduli, which are then easily converted to V_p and V_s using fluid replacement (see following section). Wang (2001) suggests a model for quartz that follows this approach, and Smith (2011) also recognizes this method, noting "variation in the dry-frame properties with porosity is an effective means for better understanding velocity-porosity systematics."

Fluid Replacement Modeling. The final absolutely essential skill for the interested or aspiring seismic petrophysicist is fluid-replacement modeling, also noted as 'do Gassmann modeling' by your (exploration) geophysicist when he/she sends you the work-request email. Fluid replacement modeling using the Gassmann relationship is essential for quantifying the impact that light hydrocarbon has on the velocity response of a hydrocarbon reservoir. Two cases are commonly encountered when using well data: (1) forward model the effect(s) of hydrocarbon (oil, gas) in a wet reservoir (the 'dry hole case'), and (2) remove the influence of hydrocarbon in a hydrocarbon-bearing reservoir (the 'discovery rock physics modeling case') so as to build/calibrate a predictive (reservoir) rock physics model and validate the seismic-based anomaly used to locate the (discovery) well. The comments that follow highlight essential modeling inputs where petrophysical care and attention to detail are necessary to keep the modeling exercise and results robust and consistent with the behavior of 'real rocks'. The emphasis in what follows is on doing fluid-replacement modeling with well data, using reservoir petrophysics inputs, but the message also applies and holds true when working with lab-measured rock physics data. Two excellent references that detail the Gassmann model and important application details are Wang (2001) and Smith et al. (2003).

The starting point for well-based modeling is the 'reservoir petrophysics' product: porosity, water saturation, and log-derived mineral volume(s), e.g., clay, 'quartz' (and feldspar, mica?), carbonate (calcite, dolomite) and where 'shaly' sand reservoirs may occur, a quantitative net-to-gross or determination of clay morphology (dispersed, laminated). We also assume that both log QC and shear-velocity QC/validation (see previous sections) have also been completed. There is no need to resort to 'approximate' Gassmann method(s) when reliable shear-velocity data are available, or a reasonable estimate of V_s can be made. The petrophysical products porosity and water saturation are direct inputs to Gassmann, and your formation mineralogy (quartz, clay, carbonate, etc.) is used to determine the grain properties (grain density, grain bulk modulus) required by the model. Given that we are doing fluid replacement modeling, it should also be understood that fluid properties inputs (bulk density, modulus) are essential, or as noted by Batzle (2010), "It's the fluids that count." All fluid properties are functions of pressure and temperature (and therefore vary as a function of depth in a given well) and relevant compositional variables (brine salinity; oil API gravity, GOR, gas gravity and gas composition). Both Castagna (1993) and Wang (2001) include details for specific fluid acoustic properties models commonly applied. With porosity, saturation, grain and fluid properties, we are now ready to apply the Gassmann model.

Using the inputs described previously, the first step in Gassmann fluid replacement is the determination of the dry-rock bulk modulus. With this value determined, we then update fluid properties for the new 'substituted' saturation scenario, calculate the new saturated bulk modulus, and then V_p. The shear velocity is modified during substitution only by the change in bulk density, as the frame shear modulus remains fixed. The most common sources of instability when applying Gassmann to well data are inappropriate porosity or grain properties, combined with inaccurate or poorly characterized fluid properties, including the impact from (log-derived) S_w. Frequently overlooked in the process is the opportunity to pause and evaluate the implied rock properties exposed when the dry-rock bulk modulus is calculated. The application of dry-rock modulus diagnostics (Kittridge, 2006) as a regular and deliberate step in the Gassmann application affords both an additional QC step and yields insight into the physical behavior of the reservoir rock.

THE ROAD AHEAD: CHALLENGES AND OPPORTUNITIES

Seismic Petrophysics is really seen as a tool for integration, particularly the deliberate connection, in rock physics space, between laboratory- and well-derived data. Geologic characterization is absolutely essential as both a model input (i.e., composition controls grain properties) and constraint (e.g., ratio of elastic moduli) to petrophysical and geophysical (rock physics) models. Further, textural variability (grain size, sorting) and clay content/morphology in siliciclastic reservoir rocks and pore shape(s) in carbonate reservoir rocks

(Kittridge, 2015) impart important controls on both transport and elastic properties. Both Smith (2011) and Kittridge, et al. (2004) stress the importance of the careful characterization and inclusion of sample-specific geologic properties in the development of rock physics models. With the incorporation of geologically-sensible analog data, additional insights and further application are possible, e.g., predrill model application to exploration stage seismic attribute risking.

Challenge 1: Rock Physics Model Development. Today, in too many instances, we still miss the opportunity for pragmatic rock physics built on multiscale data derived from the deliberate application of quantitative seismic petrophysics workflows. Too often, what passes for rock physics analyses are a collection of crossplots, made using original raw well-log digi's of data, painted on a backdrop of model recipes, commonly selected because "they are in the handbook,"' or applied because "those are what are available in the software." The data analysis should focus on a specific target reservoir, and the overlying/underlying interval responsible for the property contrast leading to seismic reflection(s). Selecting a "famous" (named) model recipe to match well data, where for example a "quartz" default was applied during analysis and the reservoir rock is a lithic arkose (Folk), yielding dry-rock properties (moduli, Poisson's ratio) incompatible with quartz, but matched with physically unrealistic or unrealizable model parameters, is not rock physics. Real, rational rock physics should aspire to be a key element of seismic petrophysics (workflows), where we adhere to the original definition given by Pennington (1997). In this manner, the seismic petrophysics workflows deliver rock physics results that are truly data-driven, are amenable to integration of both local and geologically sensible (global) analog data, and the model(s) applied are selected based on local geology, with an understanding of both the importance and sensitivity of key model parameter(s).

Challenge 2: Carbonate Reservoir Rock Physics. In this second example, I will return to the topic examined in more detail and reported previously in Kittridge (2015), where I systematically evaluated both mineralogy and pore shape(s) on the acoustic response of carbonate reservoir rocks. In this case, we will also see a data-driven example that highlights the use of porosity and mineralogy in developing a robust (forward) model for elastic properties, and in so doing, also comment on Pennington's (1997) concern about general awareness and understanding of various rock physics model(s).

A popular tenet in carbonate rock physics for some time is that the effect of varying pore shape(s) can be discerned using P-wave velocity deviations from the Wyllie (time average) model. Kittridge (2015) noted several concerns with this approach: one must first account for mineralogy (calcite and dolomite grain properties are different), and the Wyllie model doesn't actually "know" anything about pore shape(s), nor does it work with or provide a result for shear velocity. In Fig. 3, I expand on a data example previously reported (Kittridge, 2015) and add some additional measured core data to that case (Fournier, 2009). The example combines data for (nearly) pure calcite samples across a wide range of porosity. The measured data are very consistent with a model that has no pore-shape control, and a model with a single (fixed) aspect ratio, suggesting minimal pore-shape variability across this combined dataset. While the Wyllie (time average) model seems to agree well with the other models, the (positive) deviations in measured (P-wave) velocity would be taken as evidence for variable pore-shape effects. Perhaps more valuable is this case provides a data-driven example using core-measured velocity data to calibrate a forward model that could be used reliably with well data from similar in-situ (calcite) reservoir intervals.

SUMMARY

In this short note I have tried to build some foundational awareness for the practice of seismic petrophysics, with particular emphasis on the role that petrophysicists are required to play if we are to realize integration and the full potential for the quantitative interpretation of seismic products. The seismic petrophysics workflow builds on knowledge and skills already routinely applied by the petrophysicist doing "reservoir" petrophysics: porosity, water saturation, and reservoir characterization (lithology, organizational morphology, pore type(s), etc.) are all vital input to robust rock physics modeling. The active participation of the petrophysicist in applying these properties, along with density and velocity, to construct credible rock physics models should not be overlooked or underappreciated. In my experience, I have found that working with geophysicists has been every bit as rewarding—and technically stimulating—as my earlier work with EOR (waterflood, CO_2 injection) reservoir engineers. While one must learn some new language for effective communication with the geophysicist, they are eager and recognize the advantage and value-add that seismic petrophysics brings to the improved quantitative interpretation of seismic data. Petrophysicists with knowledge and skill applying density and velocity data, including design and incorporation of laboratory-based testing programs, can extend their reach away from the wellbore and into the reservoir model (and geomechanical model), and will be actively sought out for contributions across the E&P life cycle.

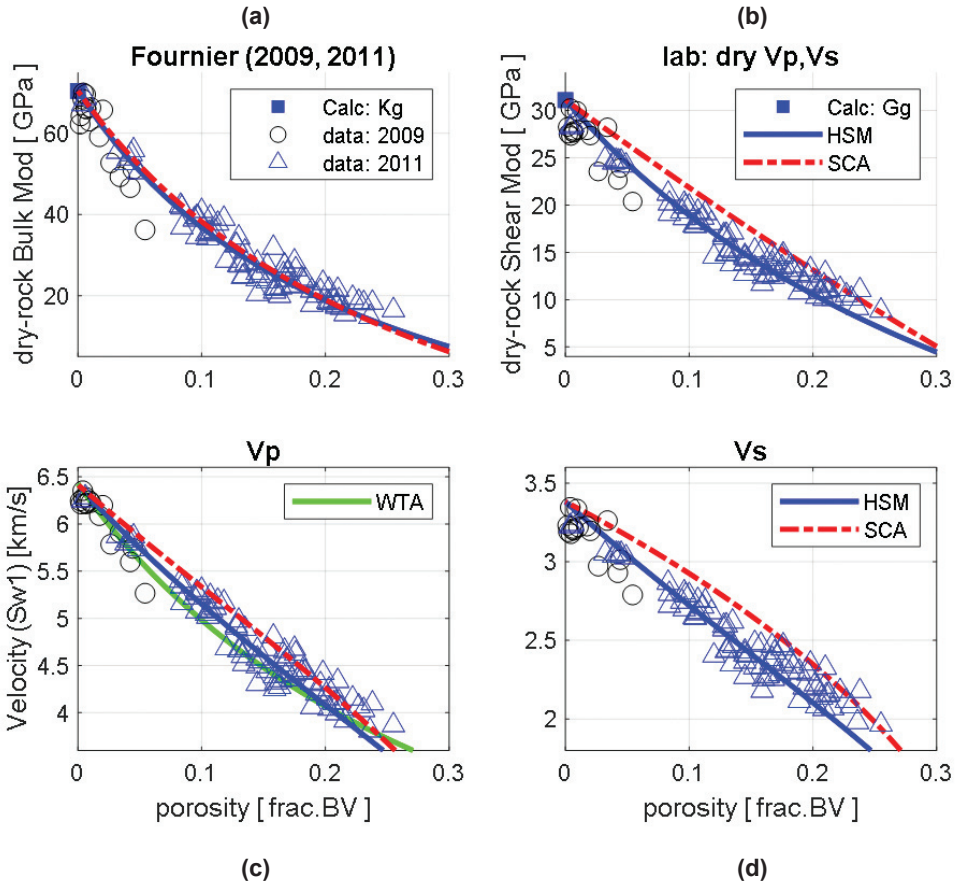


Fig. 3—Carbonate rock physics example, using data from Fournier (2009, 2011). Figure 3a and 3b show calculated bulk (a) and shear (b) moduli determined directly from measured (dry) laboratory data. The reference endpoint properties for pure calcite are also shown. The HSM model has no explicit pore-shape parameter. The SCA model uses a (single) fixed aspect ratio (α) of 0.175. Figures 3c and 3d show V_p (c) and V_s (d), after Gassmann fluid replacement to brine (S_w1), and brine-saturated models (HSM, SCA). The V_p plot also includes the Wyllie time average (WTA) for pure calcite.

ACKNOWLEDGEMENTS

The ideas described here germinated and then took root in the early 2000s while the author was fortunate to participate with, and learn from, a truly amazing and collaborative team in Shell International E&P. Key individuals included N. R. Braunsdorf, L.T. Bryndzia, T.N. Diggs, M.L. Rosenquist, S.J. Saleh, and T.R. Taylor. During the same time, I benefited from many fruitful external discussions with Keith Katahara and Tad M. Smith, which further shaped many of these views and workflows. Dr. Ronny Hofmann, formerly at the Colorado School of Mines (CSM), has always kept me grounded, and well-informed, about real rock physics work done on real rock samples. I have also had the pleasure to work with, and learn from, (the late) Dr. Mike Batzle and Dr. Manika Prasad (also CSM), and their passionate students, who kept me thinking with new questions, and new data. It was Mike Batzle who taught me the (very important) difference between lecturing and teaching, and I continue to aspire to those ideals to this day. I am grateful to Klaas Koster (Chief Geophysicist) for full support and Oxy for permitting release of this material. This paper was reviewed by Tad M. Smith, which improved the writing and technical clarity. In the end, the ideas and opinions expressed here remain those of the author.

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The references provided below represent an essential short-list for the interested reader wanting to learn more and possibly apply some of the concepts discussed in the paper. Models and workflows are described, and some relevant measured rock physics data are found in the papers included below. Clearly there are many other excellent reference papers that provide additional model(s) and data, but I find these papers to provide an excellent grounding and starting point, from which further study and investigation can follow, adding details specific to the problem at hand.

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Recent Advances in the Domain of Petroleum Fluid Properties and their Representation

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The need for fluid properties is part of the entire E&P lifecycle from exploration to mature asset management to EOR/IOR. As the projects mature, the need for such data and their integration and interpretation in the light of reservoir performance varies. Future needs for the fluid-related information are also highly related to the options (such as IOR/EOR, various well treatments, etc.) to be exercised and/or studied. In some cases, additional fluid information obtained during the surveillance/development phase can carry symptomatic information related to initial reservoir conditions (reservoir initialization) and as well as confirmation of initial assumptions about the reservoir connectivity and even architecture.

In many projects we try to predict the phase behavior, transport properties, and interactions of mixtures that contain many hundreds of components. The following questions (but not limited to) are asked quite often:

- How can we get the right specimen/sample? Would that be representative?
- How do these fluid systems flow, and how do we recover them efficiently?
- What are the minimum data requirements to define the system for a process/processes?
- What is the minimum granularity for various workflows and computational techniques?
- Project design and HSSE?
- What is the overall financial impact of the fluids on the integrated workflow?

The amount of the data required and their quality also varies during the full life cycle of a reservoir. The characterization of reservoir fluids is normally achieved via experiments (PVT data and compositions) in combination with modern EOS tools and correlations. Pressure, volume and temperature (PVT) and fluid characterization have been traditionally placed within reservoir engineering technologies due to significant impacts on in-situ volumes, recoverables, initial rates and development strategies.

Compared to two decades ago, there is significant progress in terms of enabling technologies, like modern wireline tools, in-situ analysis tools, etc. As such technologies become more affordable, their impact is being felt in a wide spectrum of projects. As we are drilling deeper and exploring in depositional environments/rocks that were not explored at commercial scales before, we are discovering increasingly more complex fluids at extreme conditions of reservoir pressure and temperature. Not only the reservoir conditions, but also a wide range of fluids is discovered in such environments increasing the compositional complexity. Combinations for both dimensions also push the envelope on hardware ratings. Such fluids span the range of lean/dry gases (acid gases/sweet gases, etc) to extra-heavy oils and bitumens. During the last decade additional complexities, such as unconventionals, came into the picture and it has become widely accepted that the behavior of the fluids is harder to isolate from what happens at the fluid-rock system interface and their further coupling, which is also proven theoretically. Furthermore, drastically low permeabilities, as low as the nanodarcy range, created additional challenges to be able to extract intact and representative specimens for our studies.

As the fluids and the reservoir conditions become more challenging, progress in the computational area is also being made, such as new EOS models and computational techniques, advanced characterization methods, etc. Beyond the highlighted complexities above, fluid data is shared with many disciplines beyond petroleum engineering (including geochemistry, geo-operations, flow assurance and process design) leading to fit for purpose analysis while putting more even more stress on integration techniques. Naturally, such integration or integration process alone generates additional constraints and requires forward thinking beyond the discipline specific workflows.

New developments in all elements of the development cycle, can mainly be categorized in the following areas:

- Multidisciplinary integration, reservoir performance management and fluid management:
  - Life cycle data management and standardization
  - Mitigation strategies for future fluids risks
  - Machine learning and data analytics and data-driven models
- Molecular simulation
- Advances in hardware design:
  - HPHT lab systems, miniaturization, automation, etc.
  - Fluid sampling
- Unconventional reservoirs: shales, tight/low-perm gas/oil reservoirs
- Reactive systems/high temperature steam injection and other thermal methods, including CO_2 EOR and CO_2 sequestration
- Complex fluid equilibria, reservoir fluid distributions and EOS fluid characterization for such systems including fluid gradients and initialization and their tie-in with the reservoir architecture

Modern project development, particularly in complex and expensive environments, relies upon integrated field development concepts. These concepts require consistent fluid properties from the reservoir to the export pipeline. Furthermore, full life cycle planning requires the anticipation and mitigation of fluid-based risks.

MULTIDISCIPLINARY INTEGRATION, RESERVOIR PERFORMANCE AND FLUID MANAGEMENT:

Especially during the last two decades, more standardized measurements at the laboratory domain have evolved. This was expected as a parallel development, as the measurements themselves became more and more automated, and also due to the use of more commoditized hardware available in the market. With the advances in desktop computing and/or accessibility of computational power almost everywhere, industrywide integration efforts became a practical reality. As such, progress was gradual with some in-between faster advances or culture change in many ways, many of the integration and coupling efforts at least became reality in digital and/or numerical sense. In addition, such integration forced the professionals to make their processes, especially in the context of handing over data from one discipline to another, compatible with each other leading to cooperative actions even at the most "primitive" data level. As our topic is fluids, a classical example is how we acquire a fluid sample considering the needs of multiple disciplines (i.e., reservoir engineers, geoscientists, flow-assurance and process engineers etc.) in advance, so that we could share the needed information with each other in a more coherent way (i.e., all data are generated in a compatible way from the same batch of fluids while reducing unnecessary complications that may arise from batch-to-batch variations, compatible fluids generated from one experiment to another experiment that will be performed later, etc.).

MOLECULAR SIMULATION AND ACCELERATION OF FLASH ALGORITHMS

The concept of molecular simulation is not new, what is new is that we finally have the computational power at our fingertips, at least for certain type of problems. Although significant progress made using simple compounds or pure or binary systems, our problems are still extremely complex (due to P-T and compositions that we encounter). Even though we have such complexities, significant progress has still been made. Molecular dynamics simulators are performed to study the behavior of ensemble of molecules that are hard to investigate using experiments. For example, molecular simulations could help in studying properties of a material that cannot be isolated easily, or for dangerous materials, or it is a good substitute for experiments that require high-temperature and high-pressure environments. As a result, molecular simulations can be devised as a complement to experiments. We must also mention one of the obvious on-going efforts in our industry, and that is our industry-wide acceleration efforts for flash algorithms and various relevant techniques that are coupled with the conventional reservoir simulators. Although the progress in this front has been somewhat slow and steady, it is still an important element to work on as the problems that are being worked on are being more and more challenging (more grids, more components, more geological complexity and a desire for real-time decision systems).

ADVANCES IN HARDWARE DESIGN

There are two main fronts in this category. Lots of progress has been made in laboratory systems. At the present time, the range of fully automated PVT cells, as well as viscometers, have reached pressures more than 30,000 psia. Some of the visual classical PVT cells can reach 300°C level temperatures at moderate pressures (3,000 psia). In addition, some of the visual micromodels have expanded pressure ranges exceeding 20,000 psia. There has been significant progress made in two categories: P-T and volume requirements. Progress in both are needed for modern PVT analysis as many of the deepwater developments are at very high P-T ranges, while acquiring large sample volumes can be quite expensive or risky. Therefore, reducing the required volumes for key measurements have wider implications, including reducing cost, time and as well as widening the envelope for various experiments that may not be possible otherwise. The role of miniaturization and microfluidics and nanofluidics in fluid analysis is increasing steadily. Some of the recent examples are: measurement of diffusion into heavy oils using microfluidic chips, CO_2-oil swelling, experiments, etc. As a consequence, it is possible to design a lab-on-a-chip (with the final goal of putting it at the sand-face and thus reducing the cycle time or achieving a real/near-real-time fluid-evaluation capability).

There has also significant progress made in the area of fluid sampling. The ability to perform sampling at various depths in one run and being able to measure selected in-situ fluid properties in real time are also part of the key recent developments. Although most of the in-situ measurements are performed using indirect proxy measurements, like the use of optical techniques (for example downhole fluid analysis via optical density measurements) rather than actual PV type of expansion/compression implementation. However, some of the miniaturization efforts and scaled down lab-on-a-chip type of initiatives can lead to bringing the lab to the sandface.

Oil-based-mud (OBM) contamination monitoring is another key capability that is achieved using downhole fluid analysis techniques to assess the time dependency of the sample quality and optimizing the timing of the physical sample acquisition. Analysis of such data can be used to calibrate numerical models for sample quality assessment and as well as new probe designs. Such calibrated models in combination with field data and newer enriched sensors lend themselves to future enhanced sampling capability and improved reservoir characterization. As we will refrain from promoting any specific products, in terms of hardware and branding, readers are encouraged to check the websites of the major service providers.

UNCONVENTIONAL RESERVOIRS: SHALES TIGHT/LOW-PERM GAS/OIL RESERVOIRS

Phase behavior and fluid properties in porous media are dominated by both fluid-fluid and fluid-solid interactions. Current industrial practice for the pressure-volume-temperature (PVT) analysis is based on modeling only fluid-fluid interactions while neglecting fluid-solid interactions. This assumption is valid for conventional systems since pore sizes are relatively large compared to the fluid mean free path. However, fluid-solid interactions play an important role in unconventional reservoirs where pore sizes are comparable to the fluid mean free path. For this reason, phase behavior and fluid properties in unconventional reservoirs could deviate significantly from their bulk values. This is often referred to as “pore proximity effect” or “pore confinement effect.” Such effect is more pronounced especially when the pore size is below 10 to 15 nm. Conventional PVT models tend to be inadequate in predicting fluid behaviors under the influence of pore proximity for such a range of pore sizes. For a long time, there was a lack of experimental data to check the validity of various proposed theoretical models (that gave quite different results with respect to each other) for these systems.

A closer look at some of these studies indicated that not all the forces are considered in many of these models and some of the calibration data based on molecular simulation results are not interpreted the same way as they were correlated with the series of hydrocarbon compounds. However recently, there is significant progress made in the area of phase behavior in nanoconfinement using microfluidics chips. This was a very important step in terms of a reality check for many of the models proposed in the literature in the context of determining the phase behavior in nanopores encountered in unconventionals. Clearly, higher precision and extremely small sensors and pressure control devices were also needed for such measurements.

REACTIVE SYSTEMS

For practical purposes, and within the production time scale, it is practical to consider the reservoir-fluid system as being nonreactive within the constraints of primary and secondary oil recovery, with the exclusion of bacterial souring or local interventions, like acidizing. However, some of the processes, such as thermal EOR and CO_2 sequestration can lead to invalidity of a nonreactive system assumption.

Among such reactive systems that involve the reservoirs, thermal EOR inherently carries various risks associated with the process itself in combination of the character of the reservoir considered. While some of the risks are common in many of the thermal processes, we will only be considering the risks associated with high-temperature steam injection as an example of thermal sulphur reduction (TSR). Designing such a steam-injection process requires various considerations. One of the key HSSE, as well as hardware integrity risks, is the generation, elevation, and/or drastic increase of acid gas production, mainly H_2S and CO_2, due to thermal souring. Generation, concentration and dynamics of the acid gas generation will have an impact in wide spectrum of areas in project design, from HSSE aspects all the way to facility design and treatment within the desired limits. Overdesigning and underdesigning of such an integrated system has inherent risks in all the aforementioned areas: from financial to go/no-go decisions to HSSE and treatment-related costs in perpetuity. Therefore, new measurement and modelling techniques are needed for such systems (in-situ-sensors, pH measurements, etc.). In such cases, the reaction kinetics will be coupled with transport and energy balance equations and can easily be modeled with the recently enhanced numerical tools. Of course, measuring the H_2S in low concentrations, regardless of the source, is one of the key challenges. Recently, such issues in a broader sense (not limited to TSR) were overcome, using newer bottle designs along with special surface-coating materials, such as Sulfinert and Dursan.

As we are facing more and more complex reservoir-fluid systems, several simplifying assumptions that were appropriate for the modeling of conventional oil and gas reservoirs, are not always valid for the more complex fields. One of these assumptions is the absence of component transfer between the aqueous phase and the hydrocarbon phases. A related assumption is the absence of chemical interactions between fluids (i.e., aqueous phase) and reservoir rock. The interaction of altered aqueous phase (i.e., dissolution of various acid gases, or other chemicals) and the rock/minerals becomes more pronounced, especially when we consider time scales on the order or orders of magnitude higher than the typical production time scales (i.e., CO_2 sequestration). In such cases, CO_2 dissolution in the aqueous phase will

make the aqueous phase no longer be an inert phase in the context of phase behavior. Therefore, new measurement and monitoring techniques, as well as numerical techniques/capabilities are developed. When reactive gases, such as CO_2 and/or H_2S are injected into the subsurface for enhanced oil recovery or greenhouse gas sequestration, phase partitioning of these gas components among aqueous and nonaqueous phases is not only a function of pressure, temperature, initial compositions of the formation fluids, but also formation mineral assemblages. This is because these gases cause reactions with some minerals, resulting in (primary, existing) mineral dissolution and possibly (secondary, new) mineral precipitation. These geochemical reactions can significantly change the brine compositions, thus impacting the amount of gas that would be dissolved in brine. Phase behavior of such systems due to polar nature of water is handled in various ways, like using Henry's law or CPA, or modified cubics with asymmetric mixing rules, such as Huron-Vidal mixing rule, etc.

COMPLEX FLUID EQUILIBRIA, RESERVOIR FLUID DISTRIBUTIONS AND EOS FLUID CHARACTERIZATION FOR SUCH SYSTEMS INCLUDING FLUID GRADIENTS AND INITIALIZATION AND THEIR TIE-IN WITH THE RESERVOIR ARCHITECTURE

For many fields, improved decision-making involves the integration of a wide variety of discipline-driven modeling, including structural and dynamic reservoir modeling, well modeling and production facilities modeling. While both discipline-specific modeling tools have significantly improved over the past decade, as well as the support for communicating between these tools, and even coupling them, challenges remain. All these are coupled with enabling technologies that determine the initial state of the systems and as well the computational techniques in hand. We define the complexities in two categories: (1) computational, and (2) system definition (that has impact on the computations).

One of the key developments in the computational area is the use of EOS. We can easily say that "EOS all the way". However, due to encountering more and more complex fluid systems (complex in terms of integrated system modeling) we are forced to make use of nonclassical cubics or EOSs in our computations. For example, in asphaltene modelling use of PC-SAFT or interaction of polar component modelling, Cubic Plus Association (CPA) or association models and as well as asymmetrical mixing rules such as Huron-Vidal found wider acceptance in the industry. However, we still have challenges in terms of the portability of these models from one discipline specific application to another. In other words, we have challenges in terms of standardization across the board for the "new players" in the EOS domain. Such issues originate from two elements: (a) inertia in EOS implementation related to cost implications, and (b) CPU constraints (i.e., complex/sophisticated but slower new models). In recent years, significant steps have been taken in terms of running EOS faster and faster and even running them at GPUs.

Another current development is the deployment of enabling technologies that are affordable for routine operations, such as wireline sampling. Due to such technologies we were able to identify various flow units in a reservoir and as well as compositional grading. As a result, we are seeing more and more graded systems that we were not aware of two decades ago. The implications of the quantification of such grading helped reservoir engineers to define the initial state of the reservoir much better than before. Augmenting other available data, such as gradient data and seismic data., we were able to say more about the reservoir connectivity as well as initial in place volumes.

Progress is inevitable and has no limits. I would like to finish this with two simple lines that represent the current progress which was once the future of yesterday and for the future of today:

- What is impossible will be easy tomorrow; and
- If you think a task/job can be done by a machine, soon it will be.

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Resistivity Tool Modeling and Log Interpretation in the 1960s and 1970s

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SPWLA Gold Medal for
Technical Achievement
2007

In 1966, I replied to an ad in a local newspaper posted by Schlumberger-Doll Research. They were looking for a mathematical programmer. Since I had recently completed graduate courses in numerical analysis and Fortran programming (and the lab was only 15 miles from where I lived) I applied. The other applicants had only keypunching experience, while I was able to show and discuss the codes I had written in class. Since the other applicants required training and I could hit the computer room running, I was hired as a programmer in the electrical logging department.

The computer in use at the lab was an EMR 6050. It was built by the Advanced Scientific Instruments Company in Minneapolis, which was renamed Electro-Mechanical Research when Schlumberger bought the company in 1964. The motivation for managing the computer company was to be better able to establish efficient data communication methods between logging trucks and log-processing centers. The 6050 had a 16 KB magnetic core memory with punched card input. It also had three magnetic tape drives that were used both for intermediate storage of modeled data, and for analyzing field data that needed special processing.

The resistivity tool modeling codes that existed in the 1960s were analytical solutions for 1D geometries (borehole and invasion without bedding, or thin beds without borehole and invasion). The basic formulations were derived from Maxwell's equations by mathematicians at the School of Mines in Paris in the 1930s. Modeling at that time was performed using mechanical calculators and slide rules. After World War II, Schlumberger and many other companies in the New York City metropolitan area leased computer time from nearby IBM before buying their own computers.

2D finite-element modeling (FEM) was attempted several times during the 1970s because the power industry had shown it to be accurate for performing generator and transformer simulations. These small-scale problems took only several hours to run, while it took several days to compute a resistivity log in a large-scale geophysical environment. 2D FEM for resistivity tools didn't became practical until the early 1980s.

However, 2D modeling is necessary for laterolog tool design and interpretation. Laterologs make shallow measurements and are often run in extremely conductive muds where borehole and invasion effects become significant. An interim solution for modeling 2D laterolog response was an analog computer built in 1952 called the Resistor Network (see Fig. 1). It consisted of tens of thousands of individually-soldered resistors configured as a borehole with four different resistivities, and a background formation resistivity of 1 Ω-m. Bed and invasion resistivities could be varied by mounting panels with different resistivity values in the bed sections.

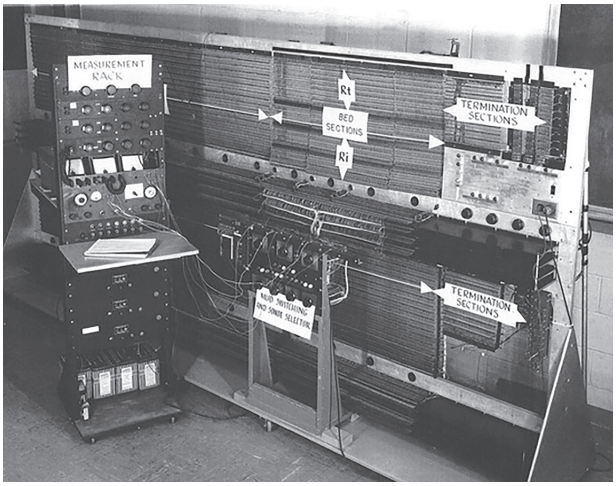

Fig. 1—Photo of the Resistor Network.

One of my first assignments in 1966 was to act as back-up technician for running the Resistor Network. I learned how to move a tool by plugging and unplugging wires that went from the measurement rack to the electrodes in the mud region. Current and voltage values on electrodes were recorded manually from readings on gauges on the rack. For fun, I was able to create equipotential maps in the formation long before FEM by clipping wires from the rack to the bed sections at intervals (that story is too long for here). The Resistor Network was retired in 1982 and moved to a museum in France.

As a learning experience, in 1968 I was involved in processing some of the first tapes received from the Alaska North Slope. The policy in research was to frequently assign tasks to people that were slightly outside their area of expertise. Management felt that this provided diverse points of view, which led to better problem solving. At the time, we knew that the North Slope was going to be an important discovery because we were told not to mention it until it was announced in newspapers.

An ongoing job during the 1970s was updating the resistivity section of the *Log Interpretation Chartbook* as new tools were introduced. Correction charts were an early form of manual inversion. Figure 2 shows an example of a Tornado Chart, which was used to obtain three formation unknowns from three resistivity measurements. The chart is created by modeling ID, IM and SFL responses for selected valued of R_m, R_t, R_{xo} and d_i. Ratios of the modeled tool responses (RIM/RID and RSFL/RID), along with R_t/RID, are calculated and plotted to obtain the chart.

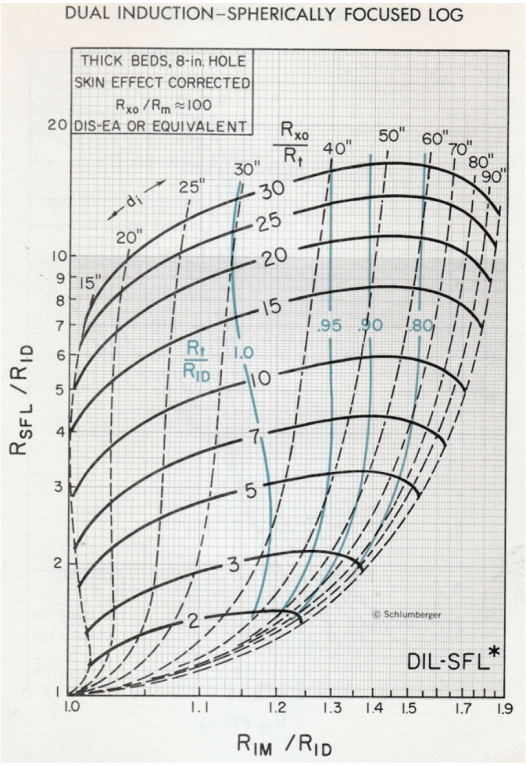

Fig. 2—Example of a Tornado Chart from a 1978 *Interpretation Chart Book*.

To use the chart, the ratios RIM/RID and RSFL/RID are calculated from log apparent resistivity readings and entered on the x-axis and y-axis. After this coordinate is plotted, R_t/RID is read from the chart and R_t can be calculated. Values for d_i and R_t/R_{xo} can also be read, and R_{xo} calculated since R_t is known. Charts were eventually converted to computer table look-up algorithms, and finally made obsolete when array tools were introduced along with their associated inversion software.

A current contributor to *SPWLA Today*, Richard Bateman, served overlapping time with me at Schlumberger in Ridgefield in the 1970s. During that time, Richard drew "Snoopy" cartoons satirizing daily life at the lab, which would mysteriously appear on bulletin boards.

One such cartoon is shown in Figure 3. The accompanying *Fable* describes problems associated with designing the SFL laterolog tool that replaced the 16-in. normal on the Dual Induction sonde in the early 1970s. The comic strip and *Fable* originally appeared in a 1972 issue of Schlumberger's in-house publication *Technical Review*. They are included here as a precautionary tale for those of you who are involved in tool design.

Barbara Anderson

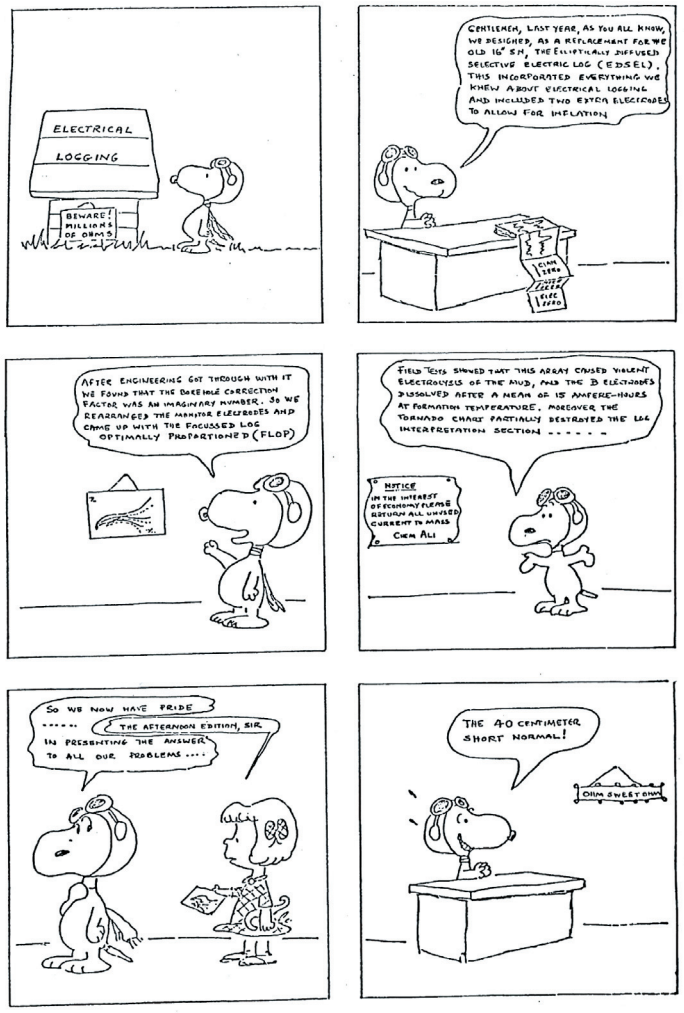

Fig. 3—A FABLE.
Once upon a time there was a 16-in. Short Normal. It was a simple tool with few problems. Because it was an unfocused tool, it was subject to borehole effect in large holes. However, with the help of several changes in electronics, it managed to hang on.

As the pace of logging continued to quicken, future regenerations seemed futile. It was decided to retire the Short Normal and find a new workhorse. Orders came down to Ridgefield to take on the task. The Resistor Network and 6050 were put to work. Midnight oil was burned by the barrel. Slowly the new Entity took form.

Its name was SFL (pronounced "siffle"). Its early track record was good. Tools were built and brochures were issued.

Then the bright picture clouded. SFL wasn't as easy going as its predecessor. It was fussy about things like hole irregularity and centering. Back it went to Ridgefield.

There was much consultation, much thought and much work. The Electrical Logging Group (Phillippe Souhaite, Stan Gianzero, Roland Chemali, Steve Denker, abetted by programmer Barbara Anderson) buckled down to the job. At one stage, borehole correction charts were coming off the plotter with the regularity of the New York Times. The domestication of the SFL was finally accomplished.

(For the benefit of those too young to remember: (1) the Edsel was a spectacularly unsuccessful American car of the 1950s; (2) the Peanuts character representing Barbara is carrying a French curve because computer plots had to be redrawn in pen and ink before they went into reports.)

E. C. Thomas

I am always pleased or disappointed to see the Thomas-Stieber methodology used/misused/cited in technical societies, e.g. SPWLA, SPE, AAPG and SEG, that accept peer-reviewed papers containing petrophysical methodology. After all, the paper was presented 43 years ago. But let's review the circumstances in order to properly understand the take-aways we present in the following paragraphs.

SETTING THE STAGE

Wireline logging in the early 1970s was analog; the tool measurements were sent up a 7-conductor cable in real time as measured downhole, routed to and measured by six galvanometers (one of the seven cable conductors was reserved for power sent down to run the tool) inside a camera. A small mirror was mounted on each galvanometer which could reflect a small light beam on to the film, thus recording the voltage sensed by the galvanometer. Additional fixed light beams recorded the standard API grids. The light reflected by the mirror was split into two separate beams and recorded on two separate film canisters. One was always a 5-in. (per 100 ft) scale and the other could be a 1- or 2-in. (per 100 ft) scale. The 5-in. print was for petrophysical use and the 1 or 2-in. print was for the geologist.

Once the logged interval was complete, the tool was pulled up into casing for safety and waited until the logging engineer took the film canisters into the small darkroom to be developed, washed, and hung to dry. Once dry enough to inspect, the decision was made that the film was satisfactorily exposed and developed. If for some reason this development step resulted in under- or overexposure to such an extent that the recorded data could not be seen, then the whole process would have to be repeated by relogging the well with that tool. Given the OK, the tool was pulled, laid out on the catwalk and after-logging calibrations performed. Before and after calibrations were compared to make sure the tool was working correctly. This comparison was used with the downhole 100-ft repeat section to make the call to proceed on to the next tool or to relog the prior run. Thus, you can see that the logging engineer needed to be an expert developing black and white film to avoid having to relog a given tool and incur lost time and added dangers. (I do not recall seeing any such skill taught in engineering classes, chemistry and physics classes. Photography classes were over in the Fine Arts Quad) The dried film was then put through a Diazo blueline printer. (Another skill not taught: Diazo printing, i.e., making a blueprint.) It was these prints, 5 in. and 1 or 2 in. that contained all the data. The logging company kept the films to make additional prints as needed. The 5-in. prints were delivered to the home of the petrophysical engineer by hot-shot, typically at 3 a.m., and the evaluated log-print was expected in the office by 7 a.m.

Now this trip down memory lane was taken just to emphasize that the data available were as-recorded analog signals with no computer manipulations, save SBR on the deep induction which was done with analog circuits. The memorization of analog signals to put all logs (e.g., 6FF40 induction run with an 1.5-in. standoff, SP, spherically focused, gamma ray, FDC run on a powered arm keeping the face of the tool against the borehole wall, using a backup arm to help the measuring pad push through the mudcake, this backup arm was used to compute a borehole caliper, and this used all 6 channels) was done by analog methods using a bank of rotating capacitors that were charged, sampled by the galvanometers, discharged, foot by foot. All signals recorded on film were then subject to analog time-constant effects and thus curves were very sensitive to logging speed, particularly those tools based on radioactive count rates. Also, one had to be *aware* of bed-thickness effects and *beware* of the guesstimate corrections for same using isotropic, infinite-bed thickness models. Finally, we had to handle effects caused by mismatched tool resolutions, both vertically and radially. The ability to run CNL and Sonic on the same tool had to wait for digital downhole multiplexing.

The result on the film is a 10-ft running average for R_t from a deep induction and a 3-ft running average with doubly-weighted center response for bulk density. The former will not resolve any bed less than 3-ft thick and the latter will not resolve any bed less than 1-ft thick. Formations composed of laminations 0.25- to 5-in. thickness will produce log readings reflective of average values without divulging to the logger that they are not homogeneous. Also, we must consider the additional effects caused by dipping beds. They start out by being second-order effects at low dips and reaching monstrous magnitudes with questionable corrections above 75° dip. What value of Archie's *n* does one use in our transform between resistivity and saturation in these unknown situations?

Lastly in this same time frame, one simply spoke of shaly sands as a homogeneous bed and developed ways to correct for the effects of homogenous dispersed authigenic clay minerals on the electric-log response-to-saturation transform, e.g., Waxman-Smits and dual-water equations. Both Monroe Waxman and Chris Clavier knew well that rocks were not homogenous everywhere; they simply chose to solve one problem at a time: dispersed clay minerals. It was the users of these equations that

were in error when they tried to make them work for the laminated system. We must recall that even Archie used homogenous samples and ignored the effects of anisotropy. The key is to always look at the rocks and see if they fit the empirical models in use. Do not be upset if your rock falls out of the empirical dataset and you never cast an eye on the cores to discover this fact, at the start of your evaluation.

THE DEVELOPMENT OF THE THOMAS-STIEBER METHODOLOGY

This development was a fit-for-purpose solution to a specific problem. The formations we were drilling and evaluating were laminated clean sand and shale with some authigenic clay minerals. All the laminations were unresolved, and at the time, unrecognized as such and treated as a homogenous, dispersed clay mineral shaly sands. The key data that led to a solution were the combination of carefully obtained well logs and whole cores. In addition, there were high-resolution core photographs of the slab in white and UV light together with accurate core analyses using methods developed by Ben Swanson, Clyde Moore, and me. Careful core-log depth correlation was critical due to the random presence of 1-, 2- and 3-in. thick shale laminations in the cored interval of 20 ft.

Core slab after core slab from many wells showed very similar results, thus the need to make a model to handle this environment. The result was the Thomas-Stieber model. We worked with beds that contained unresolved shale laminations. The model result from being applied to such beds is as follows:

1. Within the bed, we determine the net feet of clean or shaly sand containing dispersed clay minerals. Please note we do not know the thickness of any single sand lamination, just the net thickness.
2. For the sand fraction, we determine a shale-lamination corrected average porosity of the selected bed; it will always the higher than the FDC determined porosity of the bed that contains shale laminations. Of course, one can compute a value of shale porosity from the bounding shales to verify that it is less than the sand porosity. Also note, using the density log we will be use a total porosity.
3. We can compute the bulk volume fraction of dispersed shale in the averaged porosity of the shale laminations-free sand fraction.

To obtain these three vital parameters we use the Thomas-Stieber geometrical crossplot of gamma ray vs. FDC porosity of the bed. We generally section the larger bed into smaller beds (by eye, or you can write a Python script to define subbeds for you) typically using similar gamma-ray values modified by similar porosity values. We also take typical shale zones from above and below our bed. The final parameter one needs to determine is the clean-sand gamma ray and porosity. Usually the same depositional process that results in laminated shaly sands does not produce thick clean sands. So where do we get this value? Two ways: First, one uses the historical porosity-depth datasets for the area, and mine it for the TVDSS data that corresponds with our bed in question. This gives a guidance of the maximum values for a clean sand of the same geological age as an upper limit. Diagenesis will mess-up trends miserably. Your derived value can be validated with the experienced geologists working the area and blessed by the head petrophysicist. The second way, is to let the data on the Thomas-Stieber find the shale point and predict where the clean-sand point would be “if it existed at this location”. You have the reasonable limits from the sentence above, so just draw a straight line from the shale point, slightly above the shaly sand points and stopping at the clean-sand point. In some interactive programs on the open market, you use your cursor to set the shale point and sand point and the third point of the triangle is computed automatically. These DWLP programs all use digital data and make their computations on each 6-in. digi. Thankfully, they allow you to zone the log into as many smaller intervals as you wish, where you can compute average values of gamma ray and porosity in each of your defined zones and use these values to make the Thomas-Stieber plot and resulting triangle. It will be a much, much cleaner plot than one containing a 300-ft interval of 600 data points.

The other advantage of the interoperable feature of the DWLP is to plot the two logs alongside the Thomas-Stieber plot where if one places the cursor on the any point of the Thomas-Stieber plot, it will show up as marked at every spot on the log that corresponds to those values plus or minus some chosen error. This gives one comfortable feeling about where the pay sands are located.

Once one has the shale point, clean-sand point, average shaly sand porosity, sand fraction and shale fraction, one is ready to use the induction log to compute water saturation from resistivity. Remember the induction log is actually measuring conductivity, so I prefer to work in conductivity space and parse the conductivity into two parts: one due to shale and one due to sand based upon the two bulk volume fractions determined from the triangle. Once you have computed the conductivity of the shaly sand free of shale laminations, you have all the parameters for the Archie equations. If your formation water is salty, and

the bulk volume of dispersed shale is small, the Archie equation will suffice, particularly if you have core-determined values of *m* and *n* for the rock type. However, if you are working in the other end of the spectrum, i.e., fresh water and large amounts of dispersed clay minerals, I suggest using Waxman-Smits. No value of Q_v you say? Well, if a water leg is available, one can use the Thomas-Haley method to determine Q_v for each of the zoned layers.

TAKE-AWAYS

- Do not use incremental processing. Zone and work with zonal averages.
- Work in short intervals, 400± ft.
- Use smaller subzones, 15 to 20 ft.
- Make friends with a good geologist.
- Round-up core data from similar zones of interest.

ACKNOWLEDGEMENTS

The author appreciates the efforts of Editor Carlos Torres-Verdin to get me to commit this note to *SPWLA Today* and not least, just last, the careful editing and layout by our intrepid Managing Editor, Stephen Prensky, is gratefully appreciated.

Thoughts on Petrophysical Data and Model Before Applying Data-Driven Analytics

Chicheng Xu, Siddharth Misra, Srinivasan Poorna, and Mark Shouxiang Ma

(Adapted from "When Petrophysics Meets Big Data: What Can Machine Do?" 2019, SPE-195068-MS)

ARE PETROPHYSICAL DATA "BIG"?

It is still debatable whether petrophysical data can be considered big or not, and it should be treated on a case-by-case basis. In general, petrophysical data meets the following "7V" characteristics that are common to big data:

Volume – The volume of core data and conventional numerical types of logs from a single well may not be considered as big. However, the data size of a field can become significantly large as the data acquisition expands to multiple well scenarios with quite a few key wells having large datasets of advanced logs, such as sonic and NMR waveforms or borehole image logs.

Velocity – New sensor technologies, high-speed telemetries, and remote communications have enabled real-time streaming of large-volume, multiscale, and high-dimensional petrophysical data into our databases.

Variety – Petrophysical data types are extremely diverse, and include images, waveforms, numeric values with continuous and discrete depth index (refer to Tables 1 and 2 in SPE-195068-MS for a variety of petrophysical data).

Variability – Sources of variability in petrophysical data includes geological controls, such as heterogeneity, engineering factors, such as operation environments (drilling/logging), and physical sensors (i.e., tools from different vendors).

Veracity – Petrophysical data are regarded as one of the most quantitative and reliable data sources for both geoscience and engineering disciplines to use. However, data quality can still be a challenge considering the tough logging environments and the potential physical sensor failures. It is very common to have bad and noisy data that need to undergo quality control (QC) before feeding it into any machines.

Visualization – Petrophysical data can be visualized in multiple ways to reveal the meaningful trends, patterns, and clusters. Histograms, crossplots, logging track displays, and well correlation graphs are some typical methods to visualize petrophysical data.

Value – Petrophysical data play an increasingly important role in modern reservoir modeling and characterization for estimating both reserve and production. They have a large impact as well as value on business decision making.

AD-HOC CHALLENGES OF PETROPHYSICAL DATA

In addition to the commonly shared "7V" characteristics, petrophysical data have their own unique challenges in two aspects: scales and dimensions.

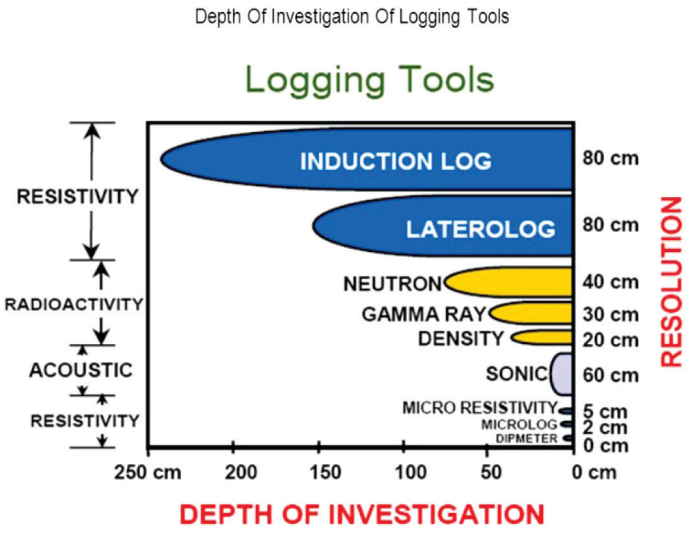

Fig. 1—Comparison of vertical resolution (vertical arrows) and radial depth of investigation (horizontal arrows) of common well logs (courtesy Professor Carlos Torres-Verdin).

Multiscale Challenge

Petrophysical data come from physical sensors that have different dimensions and resolutions. From core to logs to seismic, the scale of measurements span many different orders of magnitude. Core data can be measured on millimeter to centimeter resolution while log data are normally measured on a half to several feet resolution. Even in the well-log domain only, the scale of measurements is also variable depending on logging tool physics and vendors' tool designs. Figure 1 shows a wide range of logging tools and their resolutions, as well as their depth of investigation. As we can see, while the density logs can achieve a resolution less than 1 ft, induction logs commonly have a lower resolution of nearly 3 ft.

Multidimension Challenge

Petrophysical data can be of different dimensions depending on the physical sensor measurements. Most conventional log are 1D numerical values, waveforms are 2D,

and seismic volumes are 3D. The dimension of the integrated data also increases as more physical measurements become available. If we consider a single numerical log, such as gamma ray as 1D, then the log data will become highly dimensional by appending more logging tracks. In fact, a petrophysical dataset can be a mixture of data of different formats and dimensions. This is a unique challenge that petrophysicists need to handle.

DATA: THE BIGGER, THE BETTER?

There is a claim in the machine-learning (ML) community that bigger data gives better models or results. However, this can be a misnomer in the petrophysics area. In petrophysical workflows, the rules governing the petrophysical estimations and interpretations are driven by the available data, so data quality and quantity holds critical importance. Having bad data is considered worse than having no data. Density, representativeness, and coverage are other parameters of the data besides data quality that are required for data-driven petrophysics (Ma, 2018). Therefore, we need to pay attention to several important aspects, such as the quality and relevancy of our data, before we can make this claim true.

Data Quality

"Garbage in, garbage out" is another voice often heard in geological modeling, reservoir dynamic simulation, and the data analytics community. Regardless of the source, raw petrophysical data are often "dirty" and need rigorous and meticulous quality control by petrophysicists following protocols (Theys, 2011). Frost and Quinn (2018) discuss methods to ensure data quality and to correct environmentally affected data, data reconstruction, and statistical correction and reconstruction processes for openhole and casedhole wireline logs, as well as logging-while-drilling data. If not adequately controlled for data quality, ML engines and artificial intelligence (AI) workflows may homogenize and obscure relevant geologic and reservoir features. However, data QC work is cumbersome, especially for large field projects that contain hundreds or even thousands of wells. ML has demonstrated some advantages over humans in delivering consistent data QC work, such as depth matching. Zimmermann et al. (2018) tested ML-based methods as a new direction to tackle depth-matching issues with a fully automated solution.

Data Relevancy

Irrelevant data can also add confusion to the predictive model. Many tests have shown that use of irrelevant data will only deteriorate the accuracy and efficiency of the predictive models. The relevancy should be based on some physical or petrophysical principles. For example, gamma-ray logs are relevant to permeability in a shaly sand reservoir because they are an indicator of total clay volume, which is a controlling factor of many rock properties, such as effective porosity, pore-throat size, and permeability. But for a carbonate reservoir with an almost flat gamma-ray response, inclusion of gamma-ray logs in the permeability prediction model may not help at all. Feature selection in many old-generation algorithms needs to be performed carefully by domain experts. Many new-generation algorithms have the capability to determine the relevancy of various features and put a reduced weighting factor on features of low relevancy (Akande et al., 2015; Anifowose et al., 2016).

PETROPHYSICAL MODEL: PHYSICS BASED OR DATA-DRIVEN?

In general, petrophysical models are grounded in sound physics, referred to as mechanistic models, or developed as empirical or phenomenological models. The petrophysical models are used to quantitatively derive various petrophysical properties by processing the physical measurements obtained from core or well logs. For example, Archie's model and its variations are empirical models that are commonly used to calculate water saturation by jointly processing porosity estimations and resistivity logs (Archie, 1942). However, Archie's model involves several assumptions, such as clay-free rocks, no significant invasion, and absence of complex pore systems. Archie's model is inadequate for clay-rich, highly tortuous, and thinly laminated reservoirs (Worthington, 1997). Similarly, other mechanistic, empirical, and phenomenological models involve various assumptions for the models to be valid. When the assumptions of these models cannot be met due to the complexity, heterogeneity, and multiscale nature of the physical processes, then these models become unsuitable for petrophysical interpretations and estimations.

In some cases, the models required for petrophysical calculations need to be extremely nonlinear and nonexplicit. Mechanistic, empirical, and phenomenological models cannot account for such nonlinearity. ML methods can be used as an alternative approach to develop data-driven models for better characterization of petrophysical processes and systems. Data-driven models can provide a computationally cheaper surrogate model to substitute the costly physics-based model or provide an approximate statistical model from observations when there is no deterministic physics-based model (Aifa, 2014).

ACKNOWLEDGEMENT

A special note of thanks goes to Jeffry Hamman for proofreading and improving the manuscript.

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Machine Learning: Strengths and Weaknesses

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In Gartner's list of top 10 Strategic Technology Trends for 2019, "Artificial Intelligence (AI) Driven Development" is placed at the very top (High, 2018). In *MIT Technology Review's* 10 breakthrough technologies for 2019, curated by Bill Gates (MIT Technology Review, 2019), AI-driven automation and AI assistants are mentioned as revolutionary innovations. Terms like artificial intelligence (AI), machine learning (ML), deep learning (DL), and big data have been used interchangeably — they are related but not the same.

Artificial intelligence (AI) is a branch of computer science focused on developing algorithms inspired by certain aspects of natural intelligence to perform tasks requiring human intelligence, such as visual perception, speech recognition, problem solving and reasoning (Hodjat, 2015). AI is the grand goal—and machine learning and deep learning are some of the many techniques to achieve AI.

Machine learning (ML) is a subset of methods to achieve AI, wherein the focus is to develop algorithms that learn from large datasets, also referred as the "Big Data." ML algorithms build a data-driven model based on input data (a combination of features and targets) with an objective of using the data-driven model to make predictions, recommendations, decisions and various other intelligence-related tasks, without needing any explicitly programmed instructions/rules. Deep learning (DL) is a subset of machine-learning methods that processes "big data" to construct numerous layers of abstraction that builds functional mapping of the features/attributes to the targets. The feature-target mappings learned by the DL algorithms can be used to make predictions, recommendations, decisions and various other intelligence-related tasks. Machine learning (including deep-learning methods) builds data-driven models that improve over time as the model is fed more and more data. "Big Data" is an important component of machine learning and deep learning. "Big Data" is defined as extremely large datasets that cannot be analyzed, searched or interpreted using traditional data mining/processing methods.

In engineering and most other domains, when people say "AI" they really mean machine learning (includes deep learning) (Tran, 2017). ML works by recognizing patterns using complex mathematical/statistical techniques and algorithms, and many a times brute-force computing. Deep learning is subtly different from simple/traditional machine learning. DL methods do not require the manual step of extracting/engineering features to accomplish the learning task. DL instead requires us to feed large amounts of data to get reliable results. In addition, DL model development requires a high-performance computing to process huge data volumes at a reasonable speed. DL is a powerful pattern-recognition method, but the DL approach severely limits explainability of its outcomes and interpretability of the DL models. DL heavily relies on data annotation/labeling quality. ML/DL methods tend to be impressive when considering its statistical performance over many samples, but they can be highly erroneous in individual cases.

Over the last five years, incredible advances in machine learning have been made with the advent of deep neural networks that are trained on "Big Data" using very fast GPUs. These advances have benefited from the accumulation of digitized data and ubiquitous deployment of robust sensor systems. In addition, there is a wealth of openly available technologies that make it simpler and cheaper to build and run machine learning algorithms. Many of the tools are easily accessible and inexpensive, e.g., public clouds, like Microsoft Azure and Amazon Web Services, allowing massive data-crunching exercises without the need to buy tons of hardware (Hopkins, 2019). These advances have led to the state of the art in computer vision and speech recognition, such that machines have now exceeded the powers of human sensory perception in certain areas (Woodie, 2018).

Machine learning has ushered a whole new way of doing business by propelling progress in automation, sensor-based industrial monitoring, and algorithmic analysis of business processes. Now, computers can learn the tasks to assist humans rather than merely doing as they're told. AI as a research area has been around in computer science since the 1950s (including its subfields, such as machine learning and deep learning). The recent boom in AI implementations and their popularity has been due to better algorithms leading to improved accuracy, faster GPUs providing large compute power, large datasets for training the ML and DL algorithms, easily accessible ML platforms for developing data-driven models, and cloud-based services providing easier access to computational resources (Wurst, 2017).

Due to the proliferation of data and rapid advances in the predictive analytics, machine learning is attracting large financial investments. Venture capitalists funded 1,028 AI-related startups last year. Technical conferences and workshops promising to explain AI and demonstrate the power of AI have become a common and widespread trend. The annual meeting of the World Economic Forum in Davos in 2018 included close to 10 panels related to AI, e.g., "Designing Your A.I. Strategy" and "Setting Rules for the A.I. Race" (Cooke, 2018). Any technology advancing at a fast pace and with such breathless enthusiasm should be brought under a thorough

reality check.

Here are few tasks related to O&G upstream exploration and production that are suitable for ML/DL implementations:

- Detecting minute changes, variations, and patterns in high-dimensional datasets;
- Finding similarity and dissimilarity among systems/processes at a granular level ;
- Fast decision making by processing high-speed data flow generated from multiple sources/channels;
- Develop data-driven models that improve over time to better represent the physical processes, systems, and phenomena;
- Facilitate precision engineering and characterization, especially for diagnosis and insight generation;
- Intelligently automate mundane, repetitive, low-risk tasks.

MACHINE-LEARNING-DRIVEN SUCCESS STORIES

With widespread adoption of sensing and larger quantities of digital data within reach, there are numerous potential applications for machine learning. When humans feed well-structured data, the ML algorithms can extract patterns, trends, and relationship to recommend the most appropriate procedure to accomplish a task. Companies like Amazon and Netflix, invest heavily to train machine-learning models to build robust recommendation engines for making relevant and accurate predictions that match the users tastes/preferences. Alphabet's life sciences division, Verily, has been successful with assessment of specific disease risk and its progression to facilitate preventive measures. IBM Watson Health is discovering off-label uses of existing drugs, improving chronic disease management, and providing drug safety evaluation. ML improves speed, efficiency, and effectivity of discovery, as corroborated by many drug discovery projects. AlphaGo is one of the feats of machine learning. AlphaGo uses deep-learning techniques that combine "supervised learning from human expert games, and reinforcement learning from games of self-play".

Narrowly applied, AI will be crucial in automation, preventive maintenance, and rapid decision making. Even if AI gets the right answer only 90% of the time, the benefits of being able to instantly react to incoming data streams with certain accuracy will be extremely valuable (Woodie, 2018). Human beings have limited memory and cognitive resources for solving very complex problems. Additional help from ML models in terms of handling complexity will improve human productivity and efficiency. ML-based decision making is not affected by human emotional and physical states. Compared to human specialist, ML can process volumes of information from varied fields in a short amount of time to help generate valuable insights and reliable forecast. In addition to this, machine-learning models after robust training are immediately scalable, with the potential for simultaneous use by any number of users. When given continuous supply of data and sufficient time, ML methods can concurrently improve in both breadth and depth, unlike a human, e.g., a ML interface can be an expert in geology, geophysics, and geological engineering, simultaneously (Ismail, 2017). ML can analyze large populations to identify large-scale patterns for developing holistic approaches. At the same time, ML methods can be also designed to aggregate data for precision/personalized applications. ML will enable automation of analytical activities, such as segmentation, optimization, and predictive modeling. ML will help us reduce our efforts in repetitive, cumbersome, and unexciting tasks, availing us to take on higher-value tasks. ML is a tool for enhancing human capabilities instead of replacing humans. An important thing to remember is that all this requires human involvement, assessment, and feedback, without which it is difficult to develop reliable, consistent, robust ML/DL models.

CHALLENGES AND PRECAUTIONS WHEN USING MACHINE LEARNING

ML algorithms are only as good as the data that go into them. A trained model fails on data that are dissimilar to the training data. ML models are not suitable for edge/rare cases because the model cannot learn enough statistical information about such cases, as a result the models produce unreliable results with high uncertainty for such cases. Poor data hygiene leads to a "garbage in, garbage out" scenario. Consequently, a lot of effort is required to transform the messy, unstructured data into clean structured data suitable for being consumed by the ML model (Stephen and Jacobson, 2018). ML rely heavily on manual services for creating labels/targets/annotations and for data cleaning/preprocessing, following that additional services are required for structuring the data; all this makes the ML workflow slow, tedious, and time consuming.

ML systems are yet to figure out ways to accomplish unsupervised learning, or to learn from very limited amount of data under limited computational resources, or to train without a lot of human intervention. DL workflow requires a huge amount of information and large computational resources to succeed at even basic tasks. ML tends to perform poorly in learning new concepts and extending that learning to new contexts. A major concern is the so-called "curse of dimensionality," where having too many features/attributes (high-dimensional data) and not enough observations/samples (small dataset), hinders the model development

and performance. Also, several ML proponents ignore the complex challenges faced in the real world when taking a ML model from a research paper or a controlled study to an engineered product for real-world deployment (Black, 2016). ML practitioners have noticed that these methods generally pick up patterns and relationships that are inconsistent and do not honor logical reasoning. Such unexpected relationships and trends learnt by these methods will ultimately invalidate the results during real-world deployment. Moreover, it has been demonstrated that it is easy to trick ML models to learn inconsistent patterns or to generate unreliable results. A branch of DL referred as adversarial attacks is dedicated to developing new ways of fooling deep-learning techniques. ML-driven automated systems can be severely affected by such adversarial attacks. ML models are not suitable for edge/rare cases because the model cannot learn enough statistical information about such cases, as a result the models produce unreliable results with high uncertainty for such cases. None of the recent ML research has shown a lot of progress in these areas.

A lot of the AI/ML hype originates from the extrapolation of current trends and recent successes. When vendors describe the built-in machine-learning capabilities of their products, there are three common customer responses: (1) product capabilities are overhyped, (2) vendor's do not know what they are talking about, and (3) the customer is exhausted with yet another machine-learning product. There is a perception that when vendors are promoting their "AI platforms", these are repackaged versions of traditional business intelligence or analytical tools. The "big-data" hype a decade back was very similar to the current AI/ML wave. That time, "big data" was the new business intelligence and "big data" was projected to solve everything (Tran, 2017).

Another big challenge to the adoption of ML is whether the technical domain experts will trust and adopt the ML models. Domain experts have a limited understanding of the reasons by which an ML system makes a certain recommendation, in other words explain how an answer or insight was produced by the ML system. From a domain expert's point of view, the ML predictions/results are too generic and nonspecific—lacking deep insights. Without the interpretability of the model and explainability of the results, there is some level of faith that must be put in ML-based strategies. The biggest barrier to machine learning in several industries is the culture that values a domain expert's intuition over data-driven solutions. Quite often, the problem lies in how AI, ML, and DL are portrayed, e.g., when it is said: "neural networks are inspired by neurons in the brain" or "convolutional neural networks are inspired by human visual processing system," it is not clear to anyone outside of the inner circle how to start applying the AI technologies. They should be made aware that the barriers to entry are quite low. AI, machine learning, and deep learning are not hard-to-grasp, science-fiction concepts but are based on mathematical, statistical, and computational foundations. ML and DL may be hard to understand but are indeed simple to implement (caution: implementation is easy, but the evaluation is very challenging).

ML methods work well when a complex task requiring human intelligence is broken into simpler less-intelligent, pattern-recognition-type problems. For example, machine learning can fill missing words in a sentence and translate the sentences to different languages; however, these methods are far from deriving the concept or intent of a sentence. ML methods tend to effective for narrowly focused tasks. For example, ML-assisted conversational chatbots can now perform goal-oriented conversations: setting up an appointment between two people, wherein the goal is limited to coordinating the calendars of two people.

Irrespective of successes and failures, efforts to infuse ML into organizations are spreading like wildfire and are a reality. ML implementations, design, and approaches are evolving too fast; ML practitioners are having trouble staying abreast of leading ML practices. In a haste primarily driven by the fear of missing out, organizations are entering the ML race without sufficient planning. A premature adoption of ML adversely affects the outcomes, lending a bad name to machine learning. To avoid such scenarios, Harvard Business Review (HBR) suggests taking a portfolio approach to truly harness machine learning (Schreck et al., 2018). HBR recommends having a mix of projects, ones that have the potential to generate quick wins and long-term projects for end-to-end transformation of business processes. ML models perform the best after being exposed to large historical/real-time datasets and stringent evaluation for a certain duration of time, which ensures that the ML Models are robust to edge cases and that they do not pick up inconsistent patterns.

RECOMMENDATIONS FOR HARNESSING THE POWER OF MACHINE LEARNING

1. When you master machine learning techniques, you can truly benefit from the ever-growing vast datasets available to you. ML is a great tool to have at your disposal, like computers, word processors, and mobile phones. As computing speeds are expected to double five times over the next 10 years, machine-learning tools will serve as inexpensive tool to extract information and insights from the enormous troves of data.
2. When you plan on using ML techniques, ensure you have a large, high-quality dataset to both build the data-driven models and to test them. Also, you need to ensure that the dataset you are using for building the models

should be available in the real world for ensuring a robust deployment of the ML models. It could be argued that the data are more important than the ML algorithms because ML algorithms are only as good as the data that go into them. For example, Google, Facebook, Netflix, and Amazon are leaders in ML applications not because of their intelligent algorithms and skilled data scientists, but also because of the high-quality digital data they have about people and products.

3. A vendor's demo of ML workflow may work well on the vendor's data; this does not mean that the vendor's ML workflow will work equally well when applied to your data. Even when you see great results with your data, the real-world deployment of the ML workflow will unearth severe limitations in the ML implementations. Nonetheless, your efforts to fix these challenges will make your ML implementations more robust.
4. Domain knowledge is a very important ingredient in building effective ML models. ML users should know the limitations of ML methods and when these methods can go wrong, or else ML methods will learn relationships that are totally spurious or tend to get overtrained without us knowing about such gross errors. ML users should be aware that ML methods can pick up patterns and relationships that are inconsistent without any physical basis.
5. ML tools are very good at learning clearly defined tasks, like identifying people in photographs or accurately transcribing speech. ML tools currently cannot understand human motivations or draw nuanced conclusions. For now, ML methods work well when a complex task requiring human intelligence is broken into simpler less-intelligent, pattern-recognition-type problems.
6. Human beings have limited memory, cannot visualize data in high dimensions, and have restricted cognitive resources for solving very complex problems. ML tools help us handle complexity leading to improved human productivity and efficiency. Notably, ML tools, if designed properly, can remove human bias from decision making.
7. Large firms are using ML tools to solve large-scale, high-visibility business and engineering problems. Smaller firms should try to identify the neglected, mundane tasks and deploy ML to solve them. The hype around ML has made large firms to invest their energy on eye-catching, newsworthy, marketable tasks. Moreover, there has been massive extrapolations of current ML trends and successes towards many exciting yet superficial future scenarios. More useful applications of ML can only emerge when we try to solve mundane and "boring" applications, which may never get the limelight.

CONCLUDING REMARKS

At the start, the field of genetics didn't have any understanding or even a theory of DNA. Genetics in early days tried to answer simple, narrow tasks, such as "why some people have black hair?" In the course of few decades, with the advancements in biology, chemistry, microscopy, and computations, now we can sequence the whole human genome and understand physical basis of diseases and traits. In the same vein, the field of AI is slowly marching towards the grand vision of general intelligence and ML/DL tools are few techniques helping us progress the field of AI by harnessing the power of big data (Birnbaum, 2017). Once 3D printing and virtual reality were in their hype phase. Both the technologies are now coming out of the "Trough of Disillusionment" (Gartner Hype Cycle) with real and useful applications. At the peak of hype, these technologies were touted to accomplish grand tasks, for which they were not ready. AI/ML technologies are in the hype cycle but will soon come out of the hype much stronger and more productive. While AI and its subsets are powerful tools capable of shaping a wide range of industries and the way we live, they are not the ultimate solution to the problems faced by us and our planet.

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From Associate Petrophysicist to Development Director: An Unusual Career Path

Thaimar Ramirez
2015 – 2016
SPWLA President
2018 – 2019 Secretary
SPWLA Foundation

I grew up with a passion for engineering, I always wanted to solve problems. My parents taught me everything has a solution, this led me to always pursue my dreams and with their support, I have been able to at least try everything I have always wanted to do. With my dad being in the military, my family was moving every four years and as such there was a change of city, neighbors, school, classmates, friends, all of the sudden I was either further or closer to other family members. These changes meant I had to quickly adapt to avoid disruptions to my education and lifestyle. I learned early on in my life that adaptability and flexibility are key success factors. I kept on growing and developing appreciation for science, art, and nature.

One of the biggest decisions I had to make was what bachelor's degree I was going to pursue. After understanding my options for bachelor's degrees, I decided to enroll at a local University in my home town. The Universidad Nacional Experimental del Tachira (UNET) in San Cristobal, Venezuela, was my home for the next five years where I pursued an Industrial Engineering degree. My thought process was that this was a general engineering that could give me opportunities to work in a variety of industries. During my last year of school, I had the chance to be an intern at INTEVEP, a subsidiary of PDVSA, the Venezuelan national oil company. That's where I developed my passion for the oil and gas industry. I learned all of the laboratory procedures to conduct measurements on rocks and fluids. My intern project was to work on all documentation required for the ISO certification. However, after failed interviews in PDVSA, I quickly realized it was not easy to find a job in the oil and gas industry.

Consequenly, I decided to join my alma mater as a Lecturer. At the same time, I enrolled for a distant graduate program in economics at the University of Malaga (Spain). Being a Lecturer at the university taught me a great deal of responsibility and the importance of mentoring and helping others grow. I was still determined to work in the oil and gas industry and started preparing for an international graduate degree in Petroleum Engineering. The first challenge I had to overcome was the language barrier. I enrolled in English classes in the evenings and started watching movies and reading magazines in English, usually accompanied by a couple of pills as the headaches were unbearable. After trying very hard, I finally decided to take the TOEFL and GRE tests which were required to enroll for the graduate program.

After successfully passing the tests, Dr. Torres-Verdin and The University of Texas at Austin opened the doors to me to pursue a Master's degree in Petroleum Engineering. I still remember when I received the acceptance letter from The University of Texas at Austin. I was thrilled about this opportunity but I experienced my first disappointment very quickly when attending my first class, Drilling Engineering. I had no idea that continuing to learn English and the technical jargon were going to be a long journey. I did not know all the meanings of the word "well" particularly, a deep hole in the ground after drilling operations. The Drilling Engineering professor, Dr. Chenevert, kept on talking about the well and everything related to it while I kept on wondering what he was talking about since I only knew the word "well" as an adverb (in a good or proper manner). I realized I had to study harder and made the commitment to read as many class book chapters as possible everyday, of course with the help of an English-Spanish dictionary. After two years, I successfully graduated with a MS degree. I will forever be thankful to my family, professors, and classmates that with their guidance and encouragement made this possible.

Before graduation I had the chance to pursue an internship with Schlumberger at Las Morochas in Lake Maracaibo, where I learned all of the drilling operations and even witnessed logging operations. I was introduced to well log interpretation at The University of Texas at Austin but now witnessing logging operations and understanding where the measurements came from added even more excitement to formation evaluation. I decided to entertain to join the oil and gas industry as a Petrophysicist.

I started my career as an Associate Petrophysicist at ConocoPhillips in Houston, my first assignment was to conduct fluid substitution in one of the Nigerian basins. I found fascinating what we could do with logs. My mentor at the time, David Lewis, taught me to question datasets and to better understand well-log and core measurements. Other assignments involved Alaska and Peru. This gave me the opportunity to meet colleagues across the organization and to appreciate that well logs and core measurements can be very different in different basins. Moreover, rock and fluid properties can vary across a wide range of values.

This is where my passion for reservoir engineering began. I started pursuing more projects where the opportunity to integrate well logs, core measurements, and production profiles existed. It was fascinating to integrate static interpretation of porosity and water saturation with dynamic production profiles. Very soon after, a transfer to Alaska took place where I worked as an Operations Geologist and Petrophysicist. I was the operations geologist for the exploration projects in Alaska, replacing my predecessor, Andy Andreou, who had 30 years of experience. I felt that the expectations management had about me were very high. Andy very patiently taught me everything he could during our short overlap. I will forever remember one of his most

valuable pieces of advice, "do not make decisions when getting a phone call at 2:00 a.m. Tell them, you will call them back. Get out of bed and take your time to think about the decision and then call them back". I did this for one and a half years while being mentored in petrophysics by Wayne Campaign in Alaska and Jim Klein from the Houston office who was working some of the Alaska properties. They taught me to pursue even more integration of well logs with geology, geophysics, petrography, and fluid and core measurements.

Jim Klein also introduced me to volunteering opportunities in the oil and gas industry, especially in petrophysics. He invited me to participate on the steering committee of the 2006 Spring Topical Conference on Net Pay Determination. It was fall 2005 and I had just started my first job in the oil and gas industry. My immediate thought was that I did not know enough about net pay to be on the steering committee. I politely declined. He said that after the topical conference I would certainly achieve a deep understanding of net pay determination and that he believed I was going to do a good job as a steering committee member. He was also the President of the SPWLA.

The first time I heard about the SPWLA was when I initiated my graduate studies at The University of Texas at Austin in 2003. Upon graduation, I never thought I would be mentored directly by the President of the SPWLA in 2005 and that 10 years later I would become the 57th President of the Society. Without knowing it, serving as a steering committee member started my journey to the SPWLA Presidency. By actively participating and doing my best as a volunteer, more invitations came to the table, and as I gained confidence I started to offer to participate in other SPWLA events, either as a speaker or as a committee member.

In 2009, I had transferred from the Alaska office to the Midland office. I accepted an individual contributor assignment as the Petrophysicist of the Business Unit. In Midland, I was introduced to unconventional reservoirs starting with coalbed methane, tight-gas sandstones, and source rocks. While in the Midland office, a colleague and friend, Jesus Salazar (current President-Elect of SPWLA) asked me to run for the position of Editor for the SPWLA Houston Chapter. I decided to run and accepted the invitation. The disappointing results of losing my very first election for an entry-level officer position made me feel that it was the end of my volunteer career. He was very encouraging and told me that I could run for office again the following year. I was not convinced that I wanted to run again and to feel exposed, and even worse, slammed by someone who had a longer tenure in the SPWLA. Several days after learning the election results, I realized that more people knew my name now that I had run for office and that I had another year to continue volunteering. Therefore, more members would know me, and perhaps they would vote for me. The final push of encouragement was when I ran at a sister society conference into a colleague who I deeply admire and respect for his technical work, Hani Elshahawi. He said that despite losing several elections in the past, now, he was the President of the SPWLA.

Why did I want to hold an officer position? I wondered if I was that competitive that I wanted to run again. The real reason I wanted to run for office was that I wanted to make a difference. After running again in 2010, I won the election for the Editor position, then I continued running consecutively for two more years and served as Vice President Westside and President of the Houston Chapter. During my tenure at the Houston Chapter (2010–2013), I realized that making a difference required much more effort than I had anticipated. I thought that to accomplish more I needed to volunteer more. I continued to serve as chair of topical conferences, technology committee member, volunteered at various SIGs including cofounding the Unconventional Resources SIG, and served at the grants and scholarships committee. In 2013, I was invited by the international SPWLA Board of Directors to run for the VP Technology office. It is one of the most demanding positions on the international board but I was up to the challenge. Indeed, a very challenging position but along with the Technology Committee, we were able to implement changes, such as the e-posters, which created new paradigms. Now, after several years of implementation and continuous improvement, the paper posters are a great memory.

In 2014, I was invited to run for the President-Elect position. It was a pivotal election, as both my opponent and I represented a minority in various aspects. In 2015, I became the fourth female President, the first female to serve in the last 20 years, and the youngest professional to hold the President position. I was working in Canada then, and it is uncommon for a President of the SPWLA to be based outside the United States. It was a large responsibility weighing on my shoulders as I was holding the highest position in the organization.

The 2015–2016 SPWLA International Board of Directors had to face an additional challenge: a significant downturn in our industry. The WTI oil price reached below USD 27 in February 2016, this was about midway through my term, and thousands of colleagues had lost their jobs. My main goal was to grow the SPWLA, not only in number of members, but in the development of technology, and how we influence the industry. With the legacy from my predecessor plus an ambitious agenda of my own (as a result of listening to our members), we implemented tangible changes that added benefits to the membership, increased the outreach for a truly globalized SPWLA, and modernized the Society that resulted in what many now call "the new SPWLA". Thanks to those members who communicated messages of encouragement and constructive feedback, to the SPWLA staff, and

the team that comprised the 2015–2016 Board of Directors. Because of them, I was able to handle all the responsibilities and to manage the evolutionary process. I did not get to accomplish everything I had in mind but feel very proud of what I inherited from my predecessor, of what we did, and of what my successors are doing.

During my tenure, the SPWLA international Board of Directors worked towards financial balance and to providing ways to support membership.

We delivered the 57th Annual Symposium in Reykjavik, Iceland, June 25–29, 2016 in the middle of the downturn. The Norwegian Formation Evaluation Society (NFES) hosted us and I will forever be thankful to our sponsors, exhibitors, and members who supported us during the difficult times in the oil and gas industry.

After looking back, only then at the very top, I truly understood it is very easy to criticize when one is not the individual responsible for the actions. The fundamental question still remains: Why does it take so much effort to make a difference in a professional society? Creating change and delivering results in a short time is a very difficult task in a large organization. My best answer to the question posed is that running a professional society (or any of its subsidiaries) which is a nonprofit organization is like running a profitable company except that it is operated on a volunteer basis with little to no resources. There is a board and shareholders (members) just like in a public company. Even though we are not worried about performance reviews, raises, bonuses, and stocks in our volunteer positions at the SPWLA, the responsibilities and accountabilities are significant just like in a profit-based organization. The officers aim at successfully delivering their goals, mostly during a short term (one year), while taking care of a career and dealing with personal commitments.

After sharing my experience with you, I can say with confidence, it does not matter in which volunteer position you serve, just think of yourself as making a difference, because you are. Anything you do for the benefit of the Society and its members does “move the needle”. As you move up, the needle gets bigger and heavier, therefore, it takes more effort. As long as you feel the passion and believe in yourself, you will make a difference by accomplishing anything you are determined to. But only with those around you, whether they are family, friends, and/or colleagues, you will accomplish the unimaginable because they believe you can…and they surely make you believe you can.

While I was President of the SPWLA, my career took a turn, which defined me as a Reservoir Engineer. I had joined Apache Canada to work as the reservoir engineer of the Kaybob area. I was booking reserves and running production outlooks. I was also conducting pressure and rate transient analysis, economics, and risk assessment of major development programs while having exposure to hydraulic fracturing stimulation modeling. I also continued to work on petrophysical projects. It was my dream job, fully integration. Petrophysics is the foundation of all of the work we do in the oil and gas industry. Understanding hydrocarbon in place while integrating rock and fluid properties is the basis for many other disciplines. With the downturn, my projects turned from the highest capital to zero budget. I decided to come back to the US and I joined Occidental as a Senior Advisor Reservoir Engineer in the Analysis and Interpretation team, where I became a manager six months later.

Working on difficult problems on unconventional resources, integration with geophysics, petrophysics, geology, geochemistry and geomechanics continued to be key and a success factor in my career. I always took the fun projects but also those that nobody else wanted to work on—that gave me the opportunity to grow faster. I was changing assignments approximately every two years, expanding my horizons and getting out of my comfort zone.

Now, with almost 15 years of professional career I have been appointed Director of Development of the New Mexico Business Unit where I manage six teams with a total of 45 staff members. I am responsible for delivering field development plans of core areas, well analysis and design (production drivers and optimization), inventory growth and, of course, subsurface characterization where petrophysics plays a significant role. If you asked me for a leadership advice, I only have one: always “lead” from where you are, do not ever wait to have the “supervisor” or “manager” title to make a difference.

Thaimar Ramirez

Fig. 1—SPWLA Open House and Frank S. Millard Training Center Grand Opening in April, 2016.

Fig. 3—SPWLA UT Student Chapter in Austin, April 2016.

Fig. 4—With my predecessor, 56th SPWLA President Dave Kennedy at the Annual Conference in Abu Dhabi, May 2014.

Fig. 2— The 57th SPWLA Annual Symposium was held at the Harpa Conference Centre in Reykjavik, Iceland.

Figure 5- Meeting with JFES (SPWLA Japan Chapter) Board in October, 2015.

Tales From the Oilpatch: Part 1, The 1970s in the Gulf Coast, Land and Shallow Water Leases

E C Thomas

(Editor's note: Not everything worked or proceeded smoothly during this decade. I hope these anecdotes will be of interest even if you are less than 50 years young; they should bring grins to those who remember working during those days fondly. Who among you know what a slide rule is, or possibly even use one? We actually wrote everything down in cursive pen, and relied on typists to record it in type, with three carbon copies. Didn't you love reading files with only the 3rdcarbon copy.

Enough of this already; on to the stories.)

The Case of the Missing Supervisor

During the ultracompetitive environment bidding for offshore shelf leases, wells drilled near any open acreage were watched by scouts from every company trying to glean proprietary, inferred data from watching well operations and especially wireline logging and wireline formation tests. The more logs run, cores cut and borehole tests were performed, the higher the speculation became. The market for high powered binoculars was ripe, and sea fog cursed. So we did due diligence to keep all data gathered at the wellsite reasonably "tight", on a need to know basis. In the data-gathering chain only one manager and one supervisor in the office, plus one geologist, and one petrophysicist at the wellsite. (We won't count the mosquitos, snakes and gators in the endless dredged canals traversed to get to the site.) Telephones were not available. We had to rely on radio transmission. Scramblers were not yet available, so we radioed in code. Yep just like WW-II spy networks.

Of course, code only works if each end knows the code. We had to make up a new code for each transmission, as scouts were listening in and could make inferences from code words and actions at the site if used more than once.

Then the scary part began because the logging job was turned over to me when the tool was is any hydrocarbon-bearing zones. But the real nervous time then began when the service company man turned the film canisters over to me to develop and print. Since the film had the only recorded data (analog) a botched developing meant relogging the well (oh my!). I then took the film and the one blueline print in my briefcase into the tool-pusher's office to evaluate the log and code all the pertinent data needed to make the decision in the office whether to run pipe or plug and abandon. If it had been a rank wildcat, the well would be plugged and abandoned anyway. Can't let the scouts infer we have found any pay zones. But when I radioed my supervisor, the person on the other end of the receiver was not my supervisor—he was missing! Since he was the only other person on the face of the earth that knew the code, we had a problem. I went ahead and transmitted all my coded data and there it sat, for a few hours, before my supervisor was located. I was told that people were running around the halls yelling and trying to find him. Find him they did, and they proceeded to plug and abandon the well. Of course, I did not wait to inform the tool pusher that it was a dry hole so he could start his prep to cement it up and not waste too much rig time. Managers really do not like to see handwritten morning reports with WOE hours; that translates to "waiting on evaluation." After this small snafu, I recommended that the code be shared with the geological supervisor and that one of two always be by the radio. It wasn't long before we had a secure microwave link and scramblers. Digital logging data recording on 9-in. reel-to-reel machines was only five years away, available by 1975. Satellite transmission of encoded digital data was still 15 years in the future.

Tales From the Oilpatch: Early 1970s, Part 2, Straight Holes are Easy to Drill. Right?

E C Thomas

I have chosen for the second anecdote of my series to recall one amusing occurrence that happened on my very first training session to begin my transition from the lab to the field. I was assigned to a petrophysical engineer with five years' experience. His own education was a BS degree in petroleum engineering. I was just finishing five years at the Shell E&P Research Center. My training had all been in chemistry and worked on shaly sand core samples. I grew up in South Louisiana where the only rocks I ever saw were chert gravel on the dirt roads in my home town. My dad worked in an industry tied to sugar cane, so I learned little about the derricks, pump jacks and funny shaped blue trucks with a strange French name in and about the sugar cane fields that surrounded my home. I was really the greenest, greenie starting in Shell Oil. The fellow who hired me said, "That's just what I look for—a clean slate, uncluttered with many misconceptions delivered by university professors who never had any field experience and just didn't know any better." The brilliant man who hired me was J.H.M. "Bert" Thomeer. Bert assigned me to work with Monroe Waxman (PhD in Physical Chemistry) and Bob Sneider (PhD in Sedimentary Geology). Training was exciting and after five years my blank slate was chock-a-block stuffed with "The Shell Way" of doing things from the theoretical point of view. But I had no idea how my research was being applied in the field and what problems needed solutions in field operation. I took the Shell Phase I Technical Training in fits-and-starts when I could squeeze it into my research schedule. So off to the field I was sent after completing four training runs: the steps were: (1) Watching (and much reading), (2) hand-holding or doing together (and more reading); (3) looking over my shoulder while I did stuff (and yes, more reading); and finally (4) flying solo with final inspection by my mentor (with the realization that I would have to read journals, etc., continuously to continue to fill in my infinite lack of knowledge and to keep current with the rapid advances in petrophysics (devices and interpretation methods). This anecdote I now relate occurred during Step 1, me just tagging along.

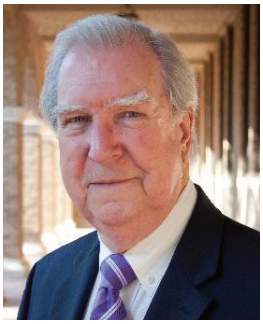
The call to meet at the airport came during late January a day after a 'Blue Norther' blew through Texas and reducing temperatures down to near freezing with gale force gusts of bitter cold wind. The plane ride to deep south Texas was not comfortable and the landing equally interesting. We proceeded to get a rent car and motel rooms and my trainer started making phone calls to the operations office in Houston concerning the ETA for wireline logging. Of course, it necessitated us being at the wellsite by 2:00 a.m. We had just enough time to get a bite to eat and drive to the wellsite. We could see the lighted derrick off in the distance and my trainer had a hand drawn map to use. The first two tries did not lead us to the derrick. Lease-line caliche roads on ranches had no signs and no lights of any sort. The third try worked and we arrived on schedule. My trainer was constantly explaining to me what to expect. He explained the mud tanks and their interconnection and the location of the mud engineer's trailer. He explained the need to have board road and board foundation for the rig. Lastly, he explained where the logging trailer was and the well foreman's office.

When we arrived at the wellsite, he noticed the lack of activity in the logging trailer and not observing any tools being set up for calibration. We went into the foreman's office and was informed that the foreman was on the rig floor. So, we donned our hard hats, bundled up to block the bitter cold wind and climbed the stairs to the lighted area. The wind had to be at gale force constantly. I was freezing my bippy off. My trainer told me to wait where I was safe, and he went to the crowd of workers to find out what was happening. It seemed like hours before he returned, but it was only 15 minutes. By then my teeth were chattering and I began to shiver. My trainer explained there would be no logging to supervise. I asked what happened and he said he would explain when we got back to the rental car and got it warmed up. I gladly heading down the stairs over to our car and got oh-so-lovely warm air.

Well what happened I asked? As it turned out I was not the only greenie on site, and the other one was ALONE on his first wellsite job. This engineer was the well survey man. He had been on site since the well was spudded and provided well inclination information using single-shot equipment run on slickline. Remember, this was before any of the MWD or inertial table equipment we use today. The single-shot equipment was run after a Kelly-down point when the drillstring is set in Kelly bushing slips and the drillstring is unscrewed from the traveling block getting ready to pick up the next stand and connect it back onto the drillstring. Now we do not run a single-shot every Kelly-down, and the frequency of runs is set by the drilling Engineer, say every sixth connection or 540 feet, or every 11 connection or 990 feet. The equipment is very simple and uses a bubble level and a light and camera to observe the bubble position, then using calibration tables convert this to inclination angle. Directional information is not obtained because the compass would be inside a heavy-walled steel drill collar and not be functional. This equipment has two sensitivity settings: 0–3° and 0–30°. The former for straight holes the latter for directional boreholes.

All you smart folks have now skipped ahead, and I explain for all.

The newbie survey engineer thought his equipment was set on the 0–3° scale but was on the 0–30° scale. He reported inclinations of 3° or less throughout the drilling process. The well was in a location with large growth faults which cause normal bottomhole drillstring assemblies to curve into the fault and build angle. When the well was surveyed at prognosed TD, the hole angle was over 75° and was thousands of feet above and west of the target and well above any hydrocarbon generation window. The result: P&A.



Richard Bateman

The Washington Post's Mensa Invitational invited readers to take any word from the dictionary, alter it (by adding, subtracting or changing one letter) and supply a new definition. An example of one of the winning entries is:

Cashtration: The act of buying a house, which renders the subject financially impotent for an indefinite period of time.

The Washington Post has also published the winning submissions to its yearly contest, in which readers are asked to supply alternate meanings for common words. An example of their readers skills included:

Flabbergasted: Appalled by discovering how much weight one has gained.

We, here at The Petrophysicist, do not wish to be left behind in matters of word play and so we hereby throw down the gauntlet and invite our readers to submit their own slight alterations to common words that we use in our daily formation evaluation tasks. As a starter I offer the following altered words and urge readers to submit their own list to the VP Publications who will then pass them on to me for inclusion in my next column.

Happy word play!

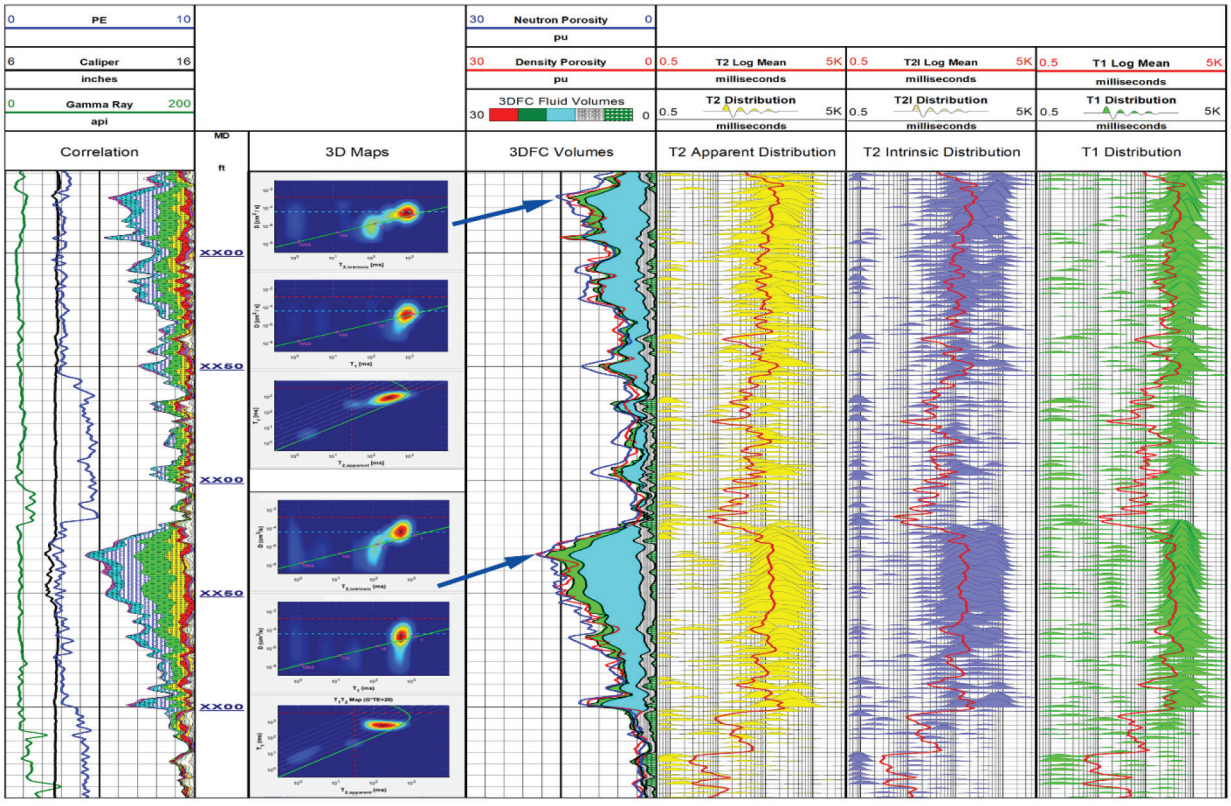
Fesistivity:	a wild party for log analysts
Forosity Log:	used to distinguish the wood from the trees
Picket Plot:	an area of land fenced off for log analysts
Vortuosity:	a measure of how quickly water drains away
Mumble Constant:	the number used for "*m*" (when you are not quite sure what to use)
Paterolog:	the father of all resistivity logs
Mompensated Density Log:	the mother of all porosity tools
Mud Tiltrate:	a measure of the speed the mud cup falls over
Blowmeter:	a measure the wind speed at the wellsite logging location
Slimestone:	a water-bearing carbonate formation
Podium Chloride:	the white powder lecturer gets from the blackboard
Pornado Chart:	a plot for dual seduction
Mingle Plot:	a mixing chart to define the matrix point and Rw
Gross Plot:	a really large X-plot
Gistogram:	a plot that gives the analyst a general idea of what the data are all about
Dud Cake:	the build-up on wall of wellbore in a dry hole
Glowout:	what's left after a blowout has been controlled
Hound Trip:	what the driller does when he is dog tired
Sagnetic Resonance:	a log trace that follows along a syncline
Perverse Fault:	one that goes the wrong way
Crack Fluid:	used by frackers
Leologist:	a rock hound born in July or August
Neologist:	a geology student who almost graduated
Teologist:	one who prays for closing contours
Detrophysicist:	an ambidextrous log analyst
Mithology:	tales about ancient Greek and Roman rocks

New-Generation Wireline Magnetic Resonance Technology

The Halliburton Xaminer® Magnetic Resonance (XMRTM) service is the newest NMR sensor in the industry. The XMR service is run in combination with openhole sensors for uplogging or downlogging, allowing for a single-pass operation. Rig efficiency is improved by combinability and higher logging speeds with NMR acquisition modes tailored to address a wide range of reservoir applications.

Data acquisition, analysis, and product delivery are available for unconventional, deepwater, clastic, and carbonate reservoir applications from 2D-T1T2 and 3D-DT1T2 solutions. As deepwater exploration often encounters high well pressure, the XMR service has a 35,000-psi pressure rating. Hole-size capability is from 5.875- to 17.5-in. bit sizes. The fast interecho spacing provides full pore-size characterization from micro to macro, and a short antenna aperture provides sharp formation-bed resolution similar to wireline density measurements.

Operators evaluating carbonate reservoirs for bypassed oil often observe unrecoverable reserves. An operator in west Texas used the XMR service to evaluate and confirm the presence of unrecoverable oil and avoided lost rig time trying to produce it. The data also validated reservoir zones that only produce saline water, preventing costly production testing of these nonproductive zones.



Carbonate example using XMRTM Three-Dimensional Fluid Characterization to evaluate residual oil.

Through-the-Bit Logging Services

The Schlumberger ThruBit* through-the-bit logging services make it possible to log geometrically complicated wells especially in the unconventional plays with greater reliability, at reduced risk, and in less time than alternative conveyance techniques. The ThruBit services portfolio includes a flexible logging suite that can be run as individual components or in triple- or quad-configurations to produce a wide range of measurement data. The full wireline measurement suite is conveyed through the drillstring and Portal* pass-through bit to log the open borehole on wireline or as the drillpipe is tripped out of the hole. With a diameter of only 2.125 in., the entire logging suite is sufficiently slim to pass through the center of most drillpipe, jars, collars, and out the opening of the Portal bit. ThruBit services can be conducted in either conventional wireline (surface readout) or memory mode, providing unparalleled flexibility in logging.

The latest additions to the ThruBit services portfolio include ThruBit FMI* through-the-bit formation microimager and ThruBit Dipole* through-the-bit acoustic service.

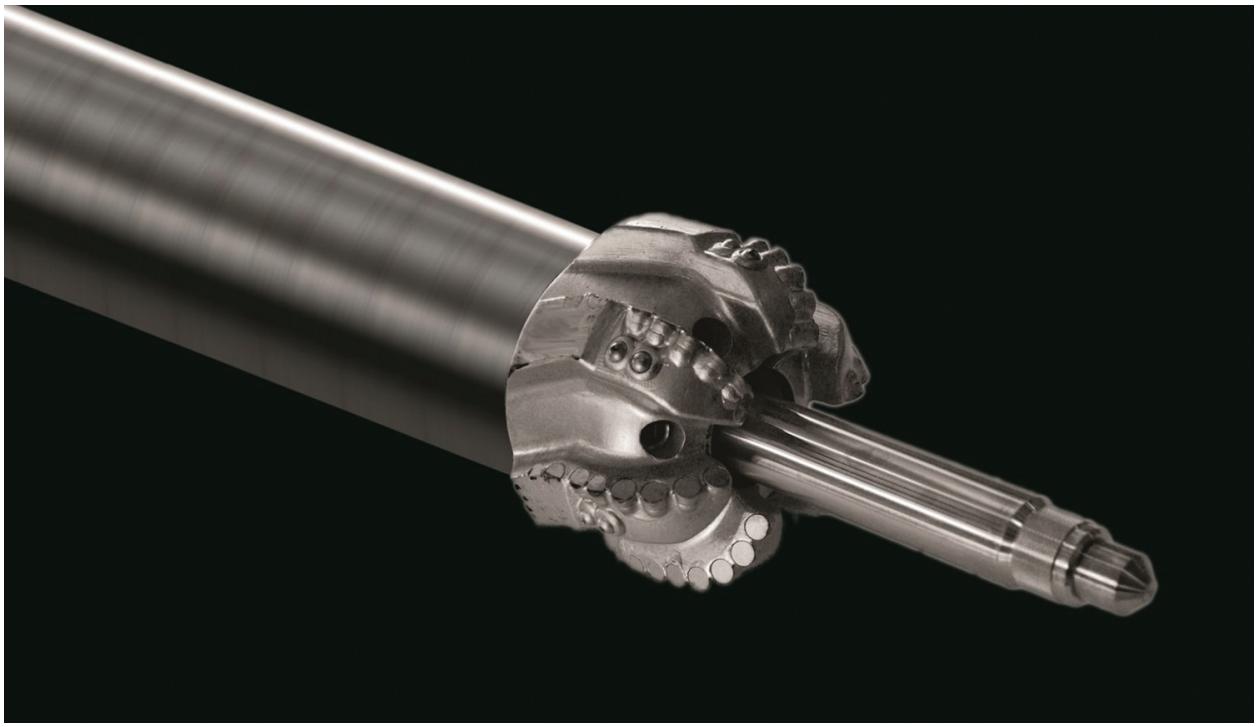
The ThruBit FMI microimager produces images in water-based muds, providing critical geological information to operators that includes fault and fracture detection, dip data, and borehole profile with up three sets of two caliper measurements.

The ThruBit Dipole service can be run in both open and cased holes to obtain monopole, crossed-dipole, and Stoneley waveforms to deliver a detailed representation of the formations. Compressional, fast and slow shear, and Stoneley slowness measurements are processed with a 3D anisotropy algorithm with respect to the borehole axes to deliver referenced anisotropic moduli. The formation can then be classified as isotropic or anisotropic, along with determining the type and cause of the anisotropy—intrinsic or stress induced. Anisotropy detection enables identifying formation heterogeneity to support the engineered design of hydraulic fracturing operations and to guide selective perforating and sand control. Well placement and stability can be evaluated by the identification of the stress regime with pore pressure data.

The use of both formation images and anisotropic acoustic data, combined with other petrophysical outputs, means that an optimized completion placement design for horizontal wells in unconventional plays can be achieved.

*Mark of Schlumberger

For further information and case studies, visit:
https://www.slb.com/services/characterization/petrophysics/wireline/platform/thrubit_logging_services.aspx



With a diameter of only 2.125 in., ThruBit logging suite is sufficiently slim to pass through the center of most drillpipe, jars, collars, and out the opening of the Portal pass-through bit.

SPWLA Young Professionals Newsletter

the bridge

A Discussion With Dr. Ravinath Kausik, Senior Research scientist, Schlumberger on Being Recognized as a 2018–2019 SPWLA Distinguished Speaker.

MAY 2019

In this edition:

Ravinath Kausik

Dr. Ravinath Kausik K.V is a Senior Research scientist of AI and machine learning at Schlumberger-Doll Research in Cambridge, Massachusetts, USA. where he has focused on the development of novel NMR and petrophysical techniques, especially of unconventional shale gas and tight oil formations. His work has led to the development of recently commercialized techniques, such as TGIP-NMR and RPI for unconventional shale gas and tight oil plays, respectively. He has also worked on the development of next generation NMR diffusion and relaxation measurements for both laboratory and downhole applications. His work has been recognized within Schlumberger with the Conrad Schlumberger prize for technical depth and the Henry-Doll prize for innovation. He has served as a Distinguished Speaker for SPWLA from 2015–2017 and is currently serving for 2018–2019. He was elected to the international advisory committee of the Magnetic Resonance in Porous Media (MRPM). He obtained a MS. from IIT Madras, India and PhD degree in physics from the Universität Ulm, Germany. He worked as a postdoctoral fellow at the University of California, Santa Barbara, before joining Schlumberger-Doll Research in 2009. He has coauthored more than 30 peer-reviewed publications and several patent applications and is a scientific reviewer for more than 10 international journals.

Congratulations on being selected as a SPWLA Distinguished Speaker. Please share with us a short description of the work that led to this prestigious recognition.

Nuclear magnetic resonance has emerged as one of the most important techniques for the evaluation of unconventional shale plays. My work that has been recognized for the SPWLA Distinguished Speakers program involves an understanding of the ability of 2D NMR T_1-T_2 measurement-based fluid typing and how this technique works at different frequencies and temperatures. The former is important for applications ranging from wireline logging, D&M logging to wellsite and laboratory measurements, while the latter is important for a more universal understanding the interpretation of 2D NMR T_1-T_2 maps from different basins, wells or depths.

How did you start your career in petrophysics and formation evaluation?

Prior to joining Schlumberger-Doll Research I was a postdoctoral fellow at the University of California, Santa Barbara, where I focused on studying diffusion of fluids across porous cell membranes. I found that my research on dynamics of fluids in porous media was directly relevant for the different kinds of problems we encounter in petrophysics and therefore enabled a seamless transition from the academic world to formation evaluation research.

What do you consider as important achievements/accomplishments in your career? How did you go about achieving those achievements/accomplishments? What were the challenges/sacrifices on the way to those achievements/accomplishments?

The biggest challenge we faced as an industry, around the time I joined Schlumberger was the evaluation of unconventional shale plays. Shale rocks with their low porosity, permeability, complex fluid types and distributions, are extremely difficult to accurately evaluate from downhole logs. Demonstrating NMR as one of the key techniques to determine unique information about these plays, is one of my satisfying research accomplishments. The answer products that we have developed for this purpose, such as 2D NMR T_1-T_2-based

fluid typing, total gas in place (TGIP) NMR for gas shale evaluation and reservoir producibility index (RPI) for tight oil shale plays are a few examples that have made an impact in this industry.

How do you convey the importance of petrophysics/formation evaluation to your colleagues from other discipline? Share with us any such interesting case.

The value of petrophysics is generally well appreciated in different sections of our industry from the field technicians to reservoir engineers to the business managers. Converting petrophysical answer products into parameters that impact the business has been the way I have found to be most successful to convey work to colleagues from other disciplines.

Please share with us few emerging petrophysical or formation evaluation concepts/workflow/methods that will benefit the upstream O&G projects?

One of the fast-growing techniques for petrophysical analysis is the application of artificial intelligence or machine-learning-based approaches. I strongly believe that in the coming years this field will have a deep impact on how we evaluate our reservoirs. This is one area where early proficiency would help budding petrophysicists establish a successful career.

What were the most useful subjects/topics/concepts you learned in college that helps you in your day-to-day work?

My background education from undergraduate to PhD is in physics and this gave me the right analytic framework and problem-solving skills, which are invaluable for developing novel petrophysical methods and answer product workflows at Schlumberger.

How were you mentored and how did you seek mentors? Share with us any valuable learning or experience shared by your mentors.

I was fortunate to start my petrophysics research career at Schlumberger-Doll Research, where we are surrounded by world-renowned experts in petrophysics. This made it easy to look ahead into the field of petrophysics, standing on the shoulders of these giants. Picking the right mentors and advisors is probably the one key factor that I believe can have the most significant impact on our careers. I would strongly advise any beginners to try and tirelessly seek expert advice help, because this would pay off handsomely in the long run.

What are the most significant changes you think the industry or your area of work has had since you started?

The emergence of shale gas and tight oil shale and the need for new petrophysical evaluation techniques and strategies targeting these plays has been one of the biggest challenges faced by the petrophysics community in the last decade. More recently, an added challenge has been to try to maintain the quality of work in an economically challenging environment, given the severe downturn in the industry.

Technical vs Management roles? What is your advice or experience for those still undecided on what to pursue in their career?

I believe that it is important to identify one's strength, and discover the roles where we can have maximum impact. The best way to do that would be to experience and experiment with different roles earlier in the career, so that we can focus on our strengths and grow organically.

What your advice to those starting their careers in the oil industry, especially to those starting in the areas of petrophysics and formation evaluation?

The field of petrophysics is fast moving with new milestones and discoveries every year. Someone starting out would do well to first get a strong foundation in the basics while also remaining open to the extensions in the technology frontier.

What advice you have for those affected by the downturn, especially when just starting in the business?

We all know that the oil and gas industry is cyclic and in the long run the focus should be on doing fundamentally important and technically valuable work, while trying to not get distracted by the financial cycles. But having said, slight tuning of the research to address challenges occurring at different periods of the financial cycle and picking the right portfolio projects would be key for a successful career in petrophysics.

A Discussion With Omar Al-Farisi on Being Recognized as a SPWLA Distinguished Speaker for 2017–2018

Omar Al-Farisi

Omar Al-Farisi is an experienced R&D Executive who has worked for Fortune Global 500 companies and academic over a 22-year career. He is the author of *Hubnomics: The Human AI Web Economy*, published by Wiley. In 2017–2018 Al-Farisi was a SPWLA Distinguished Speaker on "Strategic Management of Technology and Innovation." He has lectured on petrophysics and neural network prediction modeling at Khalifa University of Science and Technology. He is cofounder of International Abu Dhabi Research and Development Conference RDPETRO (formerly ADRAC). He is cochair of the 2019 SPE Reservoir Simulation Characterization and Simulation Conference and Exhibition. In 2016, Al-Farisi received the "Most Likely to Change the World Award" from the London Business School Student Association. He is the winner of the 2015 London Business School MBA Student Award "Most Likely to Write a Best-Selling Book." He has published more than 30 papers on business, economics, engineering, petrophysics and artificial intelligence topics. He developed the carbonates rock typing theorem "Carbonate Rock Properties Conjunction" (CROPC). Six of his publications received the ADMA-OPCO (Abu Dhabi Marine Operating Company) Innovation Award in 2006, 2009, 2010, 2011, 2012, and 2018. In 2010, his Advanced Carbonate Classification Modeling earned him a nomination for SPE's Top 10 Young Professionals Award. Al-Farisi holds a BSc degree in Electronics and Communication Engineering, and an MSc in Petroleum Engineering, and MBA Degree from the London Business School. He is a 2019 doctoral candidate at Khalifa University in collaboration with MIT in Interdisciplinary Engineering. The title of his dissertation is "Artificial Intelligence Empowered Data Analysis of Semi-Infinite-Dimension Classification." He received a Certificate in Contracts Law from Harvard University Law School. Al-Farisi has filed eight patents. His objective is to serve humanity through knowledge sharing.

Congratulations on being selected as the SPWLA Distinguished Lecturer. Please share with us a short description of the work that led to this prestigious recognition.

My team members have played a great role in this achievement. Just thanking my team members is not enough to describe their significant impact because every word they said has contributed to what we have today. When a rock typing assignment was part of a 12-month task, I had no alternatives but to do five acts: Think, Read, Ask, Try, and Learn. This is because 20 years ago, when I received an assignment, I knew nothing about rock typing. Since that first assignment, rock typing in carbonates became a love of mine that I carry everywhere and at any moment.

The main turning point in my studies in rock typing was when I identified the need to perform conjunction of properties instead of the conventional analog of properties to classify rocks. This means the Rock Type definition needs only four words, "Rocks hold similar properties." Using Boolean algebra, the definition tells us that we need to use "AND" to produce a rock type from properties, instead of the conventional use of "OR." Before I introduce the need for AND, OR directly did not work.

How did you start your career in petrophysics and formation evaluation?

Schlumberger recruited me as a logging engineer. The first time I learned formation evaluation was in ITC (Schlumberger Indonesia Training Center). Then, in moving around the world as an international logging engineer (Asia, Middle East, North Sea), clients needed logging data Interpretation, from which my experience and knowledge Increased.

What do you consider important achievements/accomplishments in your career? How did you go about achieving those achievements/accomplishments? What were the challenges/sacrifices on the way to those achievements/accomplishments?

Besides the Properties Conjunction Rock Typing, I found two essential relations between the P_c (capillary pressure) curve and permeability. Permeability and P_c are not similar but there are two critical points in the P_c curve, which I called "transition zone top" (TZT) and "transition zone plateau" (TZP). Both points form two separate linear relations with permeability.

Correcting the acid effect on neutron logs in cased holes is another achievement. This empirical model linked permeability and time to acid correction. Another correction model I have introduced is the porosity correction in the casedhole using water saturation.

I have introduced several permeability estimation methods, and each process has its own advantages and disadvantages. One of the most critical techniques in permeability estimation in carbonate rocks is the use of indexing ("normalized property").

Another important method is the use of Invasion, GR, layers and fluid zones as features to the predictor. Use of these five features was rare or used individually, but by integrating them in one approach, the permeability estimation showed drastic improvement.

Please share with us any interesting challenges you have faced in your career or technical projects.

Let's remember, the more significant the challenge, the higher the impact, according to Diamondis in his book *Bold*. The challenge was water production from a zone that I interpreted as oil zone. I was on an offshore site and I remember when the manager called me to come back to town to discuss the issue. Taking every discussion positively led to a suggestion of running a production logging tool. We ran the PLT and the results proved what we expected. Uncured cement caused leaking from a formation below, as the PLT showed, after we cured the cement water-free oil was produced.

How do you convey the importance of petrophysics/formation evaluation to your colleagues from other discipline? Share with us any such interesting case.

The petrophysicist is a critical information provider for all other disciplines. At the time the petrophysicist needs some parameters from other disciplines to enter to the interpretation models. The petrophysicist oversees full well coverage of datasets and provides them to all other disciplines. Well perforation task is a critical in the oil industry. Without petrophysicists no one would know where to perforate and how to perforate adequately and if the perforation step fails, then the well investment is lost. Other disciplines may not readily understand the impact of the petrophysicist's responsibility until they face it. In one instance, I recall the drilling manager in a meeting with field development manager (my manager) that I was attending as expert petrophysicist. The drilling manager insisted on canceling one log to meet the drilling-time plan target. I noticed that my manager was willing to support the drilling manager's request. When my manager asked me, "Omar let's help the driller and cancel the log." My only diplomatic answer was, "It is fine to cancel the log, but the driller shall pick the perforation zones." There was a moment of silence, with eyes looking at each other's, until my manager said, "we will not cancel the logging, and we will pick the perforations." Clearly, solving challenges is not about other disciplines, managers, or interpretation; instead, it is about how positive thinking can produce the best value for the organization and humanity.

Which petrophysical or formation evaluation concepts/workflows/methods do you find most useful and impactful for upstream O&G projects?

Water saturation calculation using Archie's equation is an essential and unique method for quantifying fluid saturation. Because the production decision will depend on results from this equation. In places where you have good porosity value control but no porosity log, you can still estimate porosity. But, with fluid saturations we find ourselves needing Archie's equation for openhole and for casedhole resistivity.

Integration of data; seismic, core, log, testing and production data is always important. There are no data are not useful in some way; however, optimized data acquisition is essential.

Share with us few emerging petrophysical or formation evaluation concepts/workflow/methods that will benefit the upstream O&G projects?

Digital rock physics (DRP) without any doubt will hold a valuable part from the future of petrophysics. Rock typing and determination of reservoir static and dynamic properties can benefit from DRP.

Artificial Intelligence is another trend that petrophysicist should take advantage of even more. Artificial intelligence as we know it helped a lot in permeability estimation. In the future machine learning may have the ability to solve many issues with image data (2D and 3D), core, logs and seismic data. Unsupervised machine learning can help us see features in data that we might not have thought of before.

What important skills (technical or otherwise) do you rely on in your day-to-day work? How do you keep your skills sharp?

Two main broadly defined skills are technical (knowledge) and behavioral (soft skills). Having only one of the two skills will make it difficult to continue making effective decisions. Enjoying continual learning and education was a key to keeping skills sharp. Knowledge depth and breadth both are important according to Biggs' book *Quality Teaching at the University Level.* I mentioned earlier that there are five acts that everyone can use to gain better knowledge to solve complex challenges, these are: Think, Read, Ask, Try and/or Learn. You may use one, use some, or all to address challenges. Technical skills need continual development through reading papers and performing more job tasks. But we may need to remember doing these tasks innovatively and with the passion for reaching even better results.

The behavioral skills would need the same for technical; reading, education, and practice. I list some soft skills that I found valuable and impactful: Love, Courage, Knowledge Generosity, Trust, Giving Freedom to Minds Out of all Boxes, Respecting Local Experience, Be International (Global), and Be With Your Family More.

Keep learning, not only by taking training course, but through formal education. Training and education achieve two different goals according to the book *The Gurus of Leadership*. Training helps to sharpen your mind on a single topic while schooling enables you to become sharp on many issues through integration. So, mind investment is what I did, with a BSc in Electronics Engineering, MSc in Petroleum Engineering, MBA with a focus on innovation management and now as a PhD Candidate. I would recommend an MSc after four to five years of work experience, to know where to focus. I would recommend the same for studying for MBA or PhD degrees. So, at 22 to 24 years old you get a BSc, at 30 you get an MSc, at 35 you get an MBA and at 40 get a PhD. Why I do recommend such gaps? For two main reasons, technical and behavioral. Degrees will work as a dosage of sharpening of your technical and behavioral skills in your life.

What were the most useful subjects/topics/concepts you learned in college that helps you in your day-to-day work?

In school and university, I found the six most essential subjects that everyone may think seriously about: Math, software programming, organizational behavior, strategy, economics and university level teaching.

How were you mentored and how did you seek mentors? Share with us any valuable learning or experience shared by your mentors.

My unofficial mentor was a senior petrophysicist Douglas Alexander Boyd, with whom I shared an office. I learned a lot from him. He is a generous, knowledgeable, wise, loving and hard worker. Being with him in the same office for almost three years, just made it easy for me to learn from his discussions with others and from his willingness to give comprehensive answers. Being near a wise-person is a gift, all must search, once found, learn humility in knowledge.

What are the most significant changes you think the industry or your area of work has had since you started?

Increased LWD capabilities is the most significant change that has happened since I joined the industry.

Technical vs. Management roles? What is your advice or experience for those still undecided on which to pursue in their career?

Start technical and move to managerial with time. But I recommend having an MBA before running to an administrative position otherwise it is painful to be a manager without an MBA. It is like doing engineering without having an engineering degree. Example, performing geological description without a degree in geology, you might do it but not to the best.

How do you motivate people to be interested in petrophysics and in the oil industry in general?

Without the petrophysicist, other disciplines will feel lost. Because the petrophysicist provides other disciplines with the quality data and interpretations need to make the corrects decisions, for modeling, predictions, and planning. As a petrophysicist you deals with the latest technology and can actually access to data that others can only wish for.

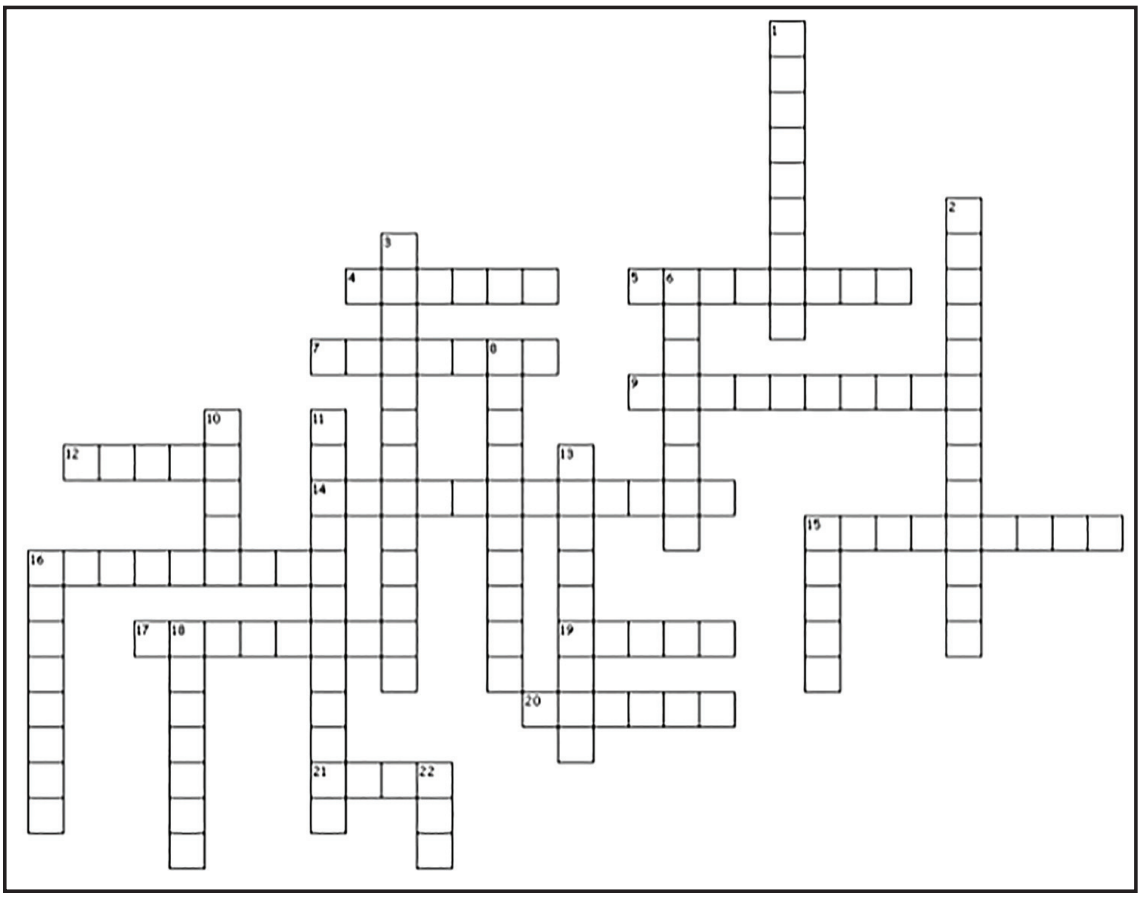
What is your advice to those starting their careers in the oil industry, especially to those starting in the areas of petrophysics and formation evaluation?

First, turn any assignment to love, and you will succeed. Every job does not precisely feel like another. There is always a new surprise, so dig, learn, try and ask until you achieve it. Help isn't still possible in unknown reservoir conditions. You are the one who knows first by trying to solve the data mystery. Start by testing your data by manually working a few data points using Excel or a calculator and interpretation charts. Then go deeper using specialized commercial petrophysics software packages.

What advice you have for those affected by the downturn, especially when just starting in the business?

The answer to downturn-affected friends is just keep Innovating, keep networking and keep learning through formal education. Moving from Industry to academia, academia back to industry is a destiny that we can be happy with. Your work experience and knowledge are not available via academia, so moving to academia will enrich and fill many gaps and allow you to do research in areas what you couldn't do when you were in industry.

Crossword Puzzle May 2019



QUESTIONS

1. Sediment size classification scale
2. Ratio of longitudinal stress to longitudinal strain
3. Key factor in neutron log response
4. High density mineral often associated with kerogen
5. Swelling clay
6. Ratio of permeability and viscosity
7. Largest continuous oil and gas deposit in USA
8. Variation of a property with direction in which it is measured
9. Physical chemical or biological alteration of sediments
10. A break in rock with observable displacement
11. Gap in the geologic record
12. Turbidite sequences generally described in units A through E
13. Core fluid saturation measurement by distillation extraction
14. Poorly sorted rocks with boulder to clay sized particles
15. (Down) Unit for permeability measurement
15. (Across) Particles moving over time in a material due to their kinetic motion
16. (Across) 6FF40 is an example of this log
16. (Down) Mud filtrate entering a permeable formation
17. Device used in seismic acquisition
18. Global sea level variations
19. First SPWLA meeting in 1959 was held in this city
20. Most popular water saturation equation
21. S2 peak on pyrolysis
22. Mineralogy analysis bas20. ed on diffraction peaks

SOLUTIONS

1. Wentworth
2. Youngsmodulus
3. Hydrogenindex
4. Pyrite
5. Smectite
6. Mobility
7. Permian
8. Anisotropy
9. Diagenesis
10. Fault
11. Unconformity
12. Bouma
13. Deanstark
14. Conglomerates
15. (Down) Darcy
15. (Across) Diffusion
16. (Across). Induction
16. (Down). Invasion
17. Geophone
18. Eustasy
19. Tulsa
20. Archie
21. Tmax
22. Xrd

SPWLA Networking Happy Hour in March 2019

SPWLA members in the Houston metro area recently gathered on a perfect weather day to network and enjoy food and drinks and have a great conversation. This was a nice opportunity to catch up and see what others are up to and even meet some of the SPWLA board members. As W.C. Fields' old quote says "Why limit happy to an hour," and that's exactly what was done during this joyful event. Attendees had the opportunity to network, meet new colleagues, reconnect with known members and talk with 2018–2019 President-Elect Dr. Jesus Salazar. Even a former SPWLA distinguished speaker, Dr. Mayank Malik, attended, giving people the opportunity to talk about diverse topics related to our society and the oil industry. It was a great opportunity especially for new members to the industry and SPWLA as well as students attending. Several students from the SPWLA University of Houston Student chapter also joined us.

A known restaurant's patio was the perfect location with a sunny day to enjoy most recent SPWLA's Happy Hour at Houston's Yard House, March 2019

Some of the attendees to SPWLA's Happy Hour at Houston's Yard House, March 2019

SPWLA professional and student members having a great time in a popular spot in H-town.

SPWLA Networking Happy Hour in March 2019

SPWLA President-Elect sharing his plans for the society and receiving input from members.

SPWLA members from all background and experience had the opportunity to interact each other.

This social event was held in a popular place in Houston, Texas. Approximately 30 professionals with diverse backgrounds and experience enjoyed a beautiful evening with drinks and food onboard. They came from operating, service, and consulting companies in addition to academia. Furthermore, new faces to this type of events attended and are motivated to continue assisting as well as regulars.

SPWLA members networking in a relaxed atmosphere with a great brew.

Food and drinks were partially sponsored by **Shale Specialists** and **TGT Oil** represented by Scott Lapierre (founder) and Julian Martin (Business Manager North & Latin America), respectively.

SHALE SPECIALISTS

TGT

SPWLA Networking Happy Hour in March 2019

It was an event full of camaraderie and joy and a great opportunity to reconnect with fellow members.

Don't Miss Our Next Event!

Join us for our next event before the summer season and the annual symposium in The Woodlands. Our second SPWLA Networking Happy Hour in 2019 will be held at Canyon Creek Café in a location accessible to anyone in the greater Houston area, on May 9, 5:00–8:00 p.m. 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!

Everybody is welcome!

When: ***5–8 p.m. Thursday May 9, 2019***

Where: ***Canyon Creek Cafe, 6603 Westcott St, Houston, TX 77007***

What is your favorite science or math joke?

Please, send us some nice jokes, memes or comic strips at spwlayp@spwla.org or through SPWLA social media, and we'll choose some responses to publish in the next issue!

Thanks for your participation.

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.

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

NMR Today and Tomorrow

Downhole, at the Wellsite, and in the Lab

Following last year's success of the first-ever SPWLA **Nuclear Magnetic Resonance Special Interest Group** conference, the **NMR SIG** has the pleasure of inviting you to join us on **June 20–21, 2019** at Southwestern Energy, 10000 Energy Dr., Spring, TX, 77389 for a 1½-day conference filled with knowledge sharing, technical training, and multidisciplinary collaboration specific to NMR petrophysics and formation evaluation.

CONFERENCE TOPICS

Rock Characterization and Integrated Petrophysics
- Carbonate pore typing, capillary pressure, permeability, pore-size distributions, wettability
- Core-log integration, case studies, added value

Hydrocarbon and Fluid Typing
- Heavy oil, viscosity, tar-mat identification
- Light hydrocarbon and gas detection
- Invasion profiling, movable hydrocarbon

Unconventional Reservoirs
- Clay-bound water, bitumen, movable hydrocarbon, surface relaxation models
- Integration with other measurements, such as mineralogy, TOC

Inversion Techniques
- Multidimensional inversions, influence of tool artifacts
- Machine learning applications, user-free interpretation

State-of-the-Art Instrumentation
- Latest developments in hardware for wireline, logging while drilling, wellsite, and lab analysis

Registration links:

(1) Both the SPWLA 2019 annual symposium & the NMR SIG conference

(2) Just the NMR SIG conference

This conference will be conducted as an "off-the-record" forum with no publication of any material presented. We encourage the presenters and participants to share their case studies, conceptual innovations, new methodologies and latest technologies. Video recording, photographing or quoting of speakers or their presentations will be expressly prohibited. Company logos should be limited to the title slide to indicate the affiliations of the author and co-authors. Commercialism during presentations is not permitted. While we have arranged this conference to follow immediately after and in the vicinity of the SPWLA 2019 annual symposium, we do not intend to repeat any presentations from the annual symposium.

Conference Registration Fee: $100 for industry professionals, $50 for students. Breakfast, lunch, and snacks are included. Social event/dinner at the end of the first day not included. Details on how to register will be communicated in the near future.

Cochairs: Nate Bachman, Philip Singer

Organizing Committee: Holger Thern, Pedro Romero Rojas, Harry Xie, Emmanuel Caroli, Boqin Sun, Songhua Chen, Paulo Netto, Ron Bonnie, Gabor Hursan, Olabode Ijasan, Scott Jacobsen.

NMR SIG Board: Mark Butler (President), Harry Xie (Vice President), Margaret Lessenger (Treasurer), Ron Bonnie (Secretary), Mike Gillen, Andrea Valori, Haijing Wang.

Society of Petrophysicists and Well Log Analysts

Petrophysical Data-Driven Analytics

SPWLA PDDA 2019 SIG Meeting

Keywords: **Machine Learning, Deep Learning, Artificial Intelligence, Petrophysical Interpretation, Reservoir Characterization**

When: **Thursday, June 20, 2019 (the day after the 2019 SPWLA annual meeting)**

Where: **Anadarko Corporation Headquarter**
1201 Lake Robbins Drive, The Woodlands, Texas 77380

Registration Fee: **Member $100, Non-SPWLA member $125, Student $50**
Registration Fee includes breakfast, lunch, and coffee breaks

PDDA SIG Meeting Committee:
Chicheng Xu (Aramco Services Company), Michael Ashby(Anadarko Petroleum Corporation), Bin Dai (Halliburton), Zheng Gan (Core Laboratories), Constantine Vavourakis(Paradigm, Emerson)

Call for Abstracts:

The committee encourages the SPWLA community to share both theories and applications of the emerging data-driven analytics methods as applicable to petrophysical data analysis, such as machine learning (deep learning) and artificial intelligence. We are seeking abstract submissions (250–500 words) on related topics including but not limited to the following areas:

- Interpretation and mapping of geological features
- Reservoir description, characterization, and modeling
- Seismic rock properties or rock physics modeling
- Well and reservoir surveillance
- Operational practices: data acquisition, quality control, standardization, and automation

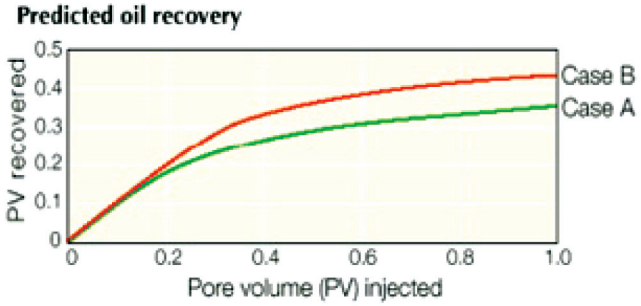
Abstract Deadline: Friday, April 19, 2019
Send your abstract to: Bin.Dai2@halliburton.com

Our Policy

- It is the policy of this organization to provide equal opportunities without regard to race, color, religion, national origin, gender, sexual preference, age, or disability.
- Conference attendance seating limited to 50. Preference will be given to applicants who are willing to present at this topical conference.
- Proceedings are “off the record” to encourage sharing of the latest techniques and information. Presentations will typically be 20–30 minutes (including Q&A). Quoting and (or) recording speakers or their presentations is prohibited.
- Commercialism in speaker presentations will not be permitted. Company logos should be limited to the title slide only and used only to indicate the affiliation of the author and coauthors of the presentation.

Comments to the “Exercise” on page 25.

First of all, let me show you the result of the simulation in the two reservoir scenarios:



Thus, Case B has a higher oil recovery, about 43% versus 36% for Case A. Surprised? Perhaps. But why is that? Consider Case A again, which has laterally extensive layers. Intuitively one thinks that the sweep efficiency in those facies with the higher permeabilities should be quite high, and that will indeed be the case. But what about the facies with lower permeabilities? There the sweep will be partially much lower than in Case B, because the more permeable layers will act as a conduit for much of the injected water, causing breakthrough in the producer while little water is being forced through the less permeable layers. In Case B though, there are no extensive high-permeability routes and the water is forced through all layers before reaching the producer, leading to a higher sweep efficiency.

Is that all there is to say about this? No, by no means. What is left out in the discussion above is the factor of time, crucial in any reservoir management because of its economic impact. It will take quite a bit longer in Case B to force the total pore volume through the entire “reservoir”, and therefore, in a NPV-world, while the sweep efficiency may be higher, the economic result may not be.

Societyof Petrophysicists and Well Log Analysts Japan Chapter
(JAPAN FORMATION EVALUATION SOCIETY: JFES)

The 25th Formation Evaluation Symposium of Japan

JOGMEC-TRC, Chiba, September 25–26, 2019

CALL FOR ABSTRACTS

Sponsored **by SPWLA Japan Chapter (Japan Formation Evaluation Society: JFES)**
Cosponsored **by Japan Oil, Gas and Metals National Corporation - Technology & Research Center (JOGMEC-TRC)**

The 25th Formation Evaluation Symposium of Japan will be held at Japan Oil, Gas and Metals National Corporation - Technology & Research Center (JOGMEC-TRC), Chiba on September 25–26, 2019. All persons involved in oil, gas, geothermal, geoengineering industry and scientific drillings are invited to submit abstracts of papers for presenting at the symposium.

It appears obvious that the market expectation for energy that has a lower impact on the environment is expanding, while the demand on fossil fuel continues. The transition of our life style from dependence on fossil fuels to so-called cleaner energy should not be abrupt with clear boundary, and the technology we have developed in the petroleum industry is in fact commonly applicable to the low CO_2 emission industry. CCUS is a good example for achieving CO_2 capture at the same time with the oil recovery enhancement. Therefore, understanding formation and reservoir characteristics still plays important role in whatever type of energy dominates in our social activity. On the occasion of the 25th anniversary of JFES, the symposium provides petrophysicists, geologists and engineers with an opportunity to share their knowledge and experience between these two energy sectors, which appear to be at at opposite positions, in the special session “low carbon emission energy.” In addition to the related topics such as methane hydrate, CCS and geothermal technology, the symposium will cover a wide range of formation evaluation, including reservoir characterization, geophysics and geomechanics applications, scientific drilling and new tool/new technology.

SPWLA Japan chapter encourage students to participate and present. **Best Student Awards** will be presented to the outstanding presentation. The student awarded would be nominated for SPWLA student paper contest in the international SPWLA2020 symposium.

NOTE TO AUTHORS: Please download the application form from the following web site, https://jfes-spwla.org/symposium/25thSymp/jfes2019.html and submit your abstract by **e-mail**. The abstract shall contain **ONLY text of 200–400 words** in English in the given form. The deadline of the submission is **June 14, 2019** and notification of acceptance will be by **July 12, 2019**. If accepted, a complete manuscript or extended abstract in English will be required for the proceedings by **August 16, 2019.**

US Copyright law requires a copyright transfer be obtained from authors of papers published in SPWLA publications. Once paper is accepted, the abstract will be published in *Petrophysics* journal and JFES homepage for the announcement of the symposium. Copyright form is signed and returned by the author at the time of submission of Extended Abstract, which subsequently takes a part of the symposium proceeding and is published on OnePetro.

If a presenting author fails to appear at the symposium to present the paper (**oral only, no poster session will be held**), the author will be subject to a two-year ban at the annual symposium and for publication in *Petrophysics*.

A name of the presenting author needs to be informed to the committee at the time of extended abstract submission. Any coauthor of the paper can replace the presenting author as long as the corresponding author have informed the Vice President of Technology in a timely manner.

(*) Any change to this policy is at the discretion of the Vice President of Technology and will be studied on a case by case basis to cover the event of sudden illness among other critical situations.

ABSTRACT IS DUE NO LATER THAN JUNE 14, 2019

Submit abstracts to:
Aiko Takada
Director, SPWLA Japan Chapter (JFES)
c/o Japan Petroleum Exploration Company
Sapia tower, 1-7-12, Marunouchi, Tokyo,
100-0005 Japan
Telephone: +81-3-6268-7290

E-mail: symposium@jfes-spwla.org

ABU DHABI CHAPTER

General News

We are pleased to announce the following individuals as our new board of directors 2019–2021.

We look forward to working with our members to continue supporting the local chapter. The Chapter encourages all petrophysicists interested to join and become active members. If you want to be added to our email list, please email us at admin@spwla-abudhabi.com. We look forward welcoming you!

Recent Events

24 March 2019 – The chapter hosted a technical talk by Brian Hornby (Halliburton) on "Achieving Business Value Using Borehole Sonic Data" at ADNOC Headquarters Rig Theatre.

SPWLA Abu Dhabi March 2019 meeting. Brian Hornby presenting at ADNOC HQ Rig Theatre.

14 April 2019 – The chapter hosted a technical talk presented by David Wunsch (CORSYDE International) on " Full Diameter Pressure Coring for Hydrocarbon Saturation Determination and Fluid Composition Analysis."

SPWLA Abu Dhabi April 2019 meeting. David Wunsch presenting at ADNOC HQ Rig Theatre.

AUSTRALIAN 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.

2018 Committee members

President	Adrian Manescu
Vice President/Assistant Treasurer/Newsletter Coordinator	Wesley Emery
Secretary	Callum Rideout Company
Treasurer	Matthew Shaw
Website Coordinator/Data Standards Focal Point	Martin Storey
Secretary/Inter-Society Liaison/Social Coordinator/ Special Events and Awards	Leanne Brennan
Monthly Meeting Coordinator	Meretta Qleibo
Membership Coordinator	Siobhan Lemmey
New Technology Forum Coordinator	Ben Van Deijl
New Technology Forum Coordinator	AbdelRahman Elkhateeb
Education Group Leader	Matthew Josh, Paul Pillai
Audio Visual Coordinator	Nigel Deeks
Sponsorship Coordinator	Andrea Paxton
Audio Visual Coordinator	Yang Xingwang
Victoria Representative	Matthew Durrant
NSW Representative	Harris Khan

Recent Events

12 February 2019 – The monthly technical presentation was by Jie Zou, (PhD Student Petroleum Engineering, WA School of Mines) whose topic was "A Prediction Model for Methane Adsorption Capacity in Shale Gas Reservoirs." The subject and topics presented were well received with a great deal of discussion and sharing of ideas.

FESAus February 2019 meeting. Speaker Jie Zou (PhD Student Petroleum Engineering, WA School of Mines).

12 March 2019 – James Dolan, (Schlumberger) gave a presentation on "Case Studies and Applications of the New High-Resolution Integrated Resistivity and Acoustic LWD Imager in Oil-Based Mud." James's talk was well received with a great deal of discussion and sharing of ideas. The subject and topics presented were well received with a great deal of discussion and sharing of ideas.

FESAus March 2019 meeting. Speaker James Dolan, (Schlumberger).

09 April 2019 – Jean-Baptiste Peyaud, (Consultant) gave the technical presentation titled "A New Nondestructive Technology for Core Analysis." The talk presented the technology and its potential, and then illustrate it with an example from Chrysaor 2. This well was chosen for the length of its core and the extent of the data available, covering mineralogy, porosity, permeability, MICP and relative permeability. The data extracted from the virtualized core will be compared to the historical data. Jean-Baptiste's talk was well received with a great deal of discussion and sharing of ideas. All subject and topics presented were well received with a great deal of discussion and sharing of ideas.

FESAus April 2019 meeting. Speaker Jean-Baptiste Peyaud (left) receiving speaker's gigt from FESAus Vice President Wesley Emery.

Bangkok Chapter March 2019 meeting. Numan Phettongkam (left) presenting the speakers gift to Alexander Beviss (right).

BANGKOK (THAILAND) 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. There is no charge for nonmembers with email registration prior to the meeting. Students are always free of charge.

Please visit the chapter website at 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
Communications	Alexander Beviss
Secretary	Ronald Ford
Treasurer	Sirinya Mahko
Student Liaison	Kruawun Jankaew
Member at Large	Damrongsak Chantipna
Technical Programs Coordinator	Numan Phettongkam

Recent Events

28 Mach 2019 – Alexander Beviss (E&P Geo Field Services Senior Geologist and Operations Manager, Thailand) gave presentation entitled, "Finding Hydrocarbons vs. Finding Traps—A Geochemical Advantage." This was a very interesting presentation on the use of geochemical analysis to identify subsurface hydrocarbons.

25 April 2019 – Ryan Banas (Apache Corporation Reservoir Engineer) gave a presentation on "Improved Efficiency and Log Quality via Automatic Well Log Editor." Ryan presented a proven workflow to improve overall data quality, as well as operational efficiency, using the "Auto Edit User Program for Interactive Petrophysics". A systematic workflow using linear regression was presented, and the advantages of using this system were explained.

Upcoming Events

30 May 2019 – Toon Puttisounthorn (Schlumberger) will give a presentation on "Downhole Sand-Production Evaluation for Sand-Management Applications."

BOSTON CHAPTER

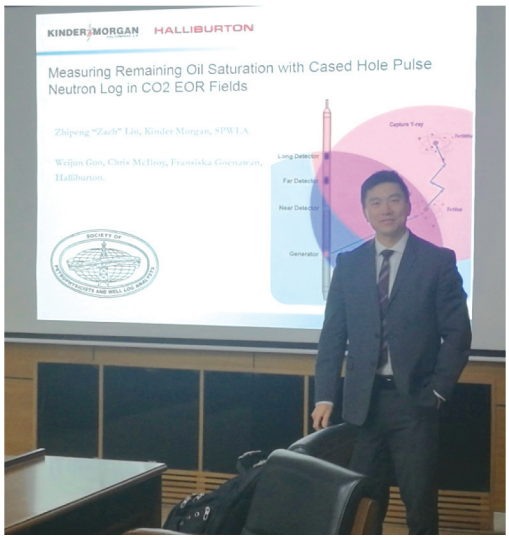
General News

The Boston Chapter is proud to say that Chapter Officer Lin Liang (Schlumberger) was elected to the SPWLA International Board of Directors as Vice President Information Technology (2019–2021)!

Recent Events

04 April 2019 – The Boston Chapter hosted Alberto Ortiz (Principal Petrophysicist at YPF S.A.), for his SPWLA Distinguished Speaker lecture titled "What have we learned from petrophysical evaluation of the Vaca Muerta formation during the last 5 years of unconventional shale play exploration and development?" The talk was highly informative and well-received!

Boston Chapter, April 4, 2019 meeting. Chapter President Ravinath Kausik (right) presents Alberto Ortiz (YPF S.A.) with his speaker plaque as a token of appreciation, together with Chapter officers Lin Liang (left) and Paul Craddock (second from left).



CUPB March 2019 meeting. SPWLA President Zhipeng (Zach) Liu was giving his presentation.

19 April 2019 – The Boston Chapter hosted a talk by Robert Kleinberg (Senior Fellow, Boston University Institute for Sustainable Energy and Senior Research Scholar, Columbia University Center on Global Energy Policy) titled "Business Cycles and Innovation Cycles in the U.S. Upstream Oil & Gas Industry."

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

CHINA UNIVERSITY OF PETROLEUM IN BEIJING (CUPB) STUDENT CHAPTER

Recent Events

25 March 2019 – SPWLA President, Mr. Zhipeng (Zach) Liu, was invited to China University of Petroleum in Beijing (CUPB) to conduct academic exchanges and was warmly welcomed by teachers and students. Mr. Liu first gave a detailed introduction to SPWLA and encouraged the teachers and students of CUPB to actively participate in various activities organized by the association. Subsequently, Mr. Liu gave a presentation on "Measuring Remaining Oil Saturation with Cased Hole Pulse Neutron Log in CO_2 EOR Fields." His topic stimulated strong interest from teachers and students of CUPB and there was a long question and answer session following the presentation. Mr. Liu's trip brought great benefit to the teachers and students of CUPB.

CUPB March 2019 meeting. SPWLA President Zhipeng (Zach) Liu and the participants.

Upcoming Events

29–30 April 2019 – SPWLA Beijing Spring Workshop on "Digital Rock, Pore Structure and Dynamics: Physics, Methods and AI"

CHINA UNIVERSITY OF PETROLEUM (EAST CHINA)

Recent Events

25 March 2019 – SPWLA President, Mr. Liu Zhipeng, was invited to visit China University of Petroleum (East China). Mr. Liu attended a symposium hold by the department of Well Logging. During the symposium, Professor Zhang, the director of the East China Chapter of SPWLA, introduced the developments and improvements of the East China Chapter and Mr. Liu offered valuable advice for future development of the Chapter.

CUPEC March 2019 meeting. Symposium with SPWLA President Mr. Zhipeng Liu.

Accompanied by professors and experts, Mr. Liu visited the teaching laboratory and acoustic logging laboratory, and showed high interest in the development of equipment and technology.

In the afternoon, Mr. Liu was invited to participate in the academic exchange activities with three professors who had studied abroad. Mr. Liu gave a presentation titled "Measuring Remaining Oil Saturation with Cased Hole Pulsed Neutron Log in CO_2 EOR Fields." At the beginning of the presentation, Mr. Liu first introduced the students and teachers of well logging to the SPWLA organization, membership benefits and scholarship, and encouraged everyone to become the members of SPWLA. The presentation on Remaining Oil Saturation technology generated great interest among participating teachers and students.

Later, Drs. Wang Lei, Zhang Quanying and Xu Song also gave presentations titled, "Fast Inversion of Deep and Extra-Deep Logging-While-Drilling Directional Resistivity Measurement," "Mechanism Analysis, Innovation and Prospect of Sourceless Density Logging Technology," and "Integrated Acoustic Evaluation of Anisotropy: From Rock Physics to Borehole Acoustic Measurements," respectively. Mr. Liu made comments on their research, and highly praised the academic achievements of the three experts.

Following the technical presentations, Mr. Liu and the professors had a deep discussion on the development of the SPWLA organization. Mr. Liu said SPWLA is undergoing major innovations and invites more Chinese workers in well logging to join, and hopes that China well logging can establish a closer tie with international logging. Finally,

CUPEC March 2019 meeting. Visiting the teaching laboratory and acoustic logging laboratory.

CUPEC March 2019 meeting. Group photo with SPWLA President Zhipeng Liu.

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 for members and guests are welcome to attend. Visit the DWLS website at www.dwls.spwla.org to make your luncheon reservations, renew your membership, or join the society.

Recent Events

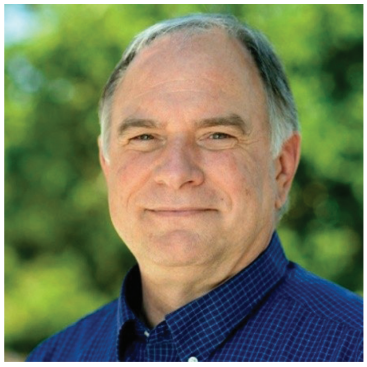
03 April 2019 – The DWLS Spring Workshop on "Data Analytics in Reservoir Evaluation" was held at the American Mountaineering Center in Golden, Colorado. Ten speakers educated attendees on topics that included data mining, predictive analytics, and different algorithms in artificial intelligence like machine learning, neural networks, and genetic algorithms. The workshop was well attended.

16 April 2019 - The April DWLS luncheon speaker was Marcus Donaldson (Mount Sopris Instruments), who presented his lecture, "The Expansive Case for Magnetic Resonance Logging." Recent developments in slimbore magnetic resonance have opened up the applications for the technology. His talk demonstrated the broad range of magnetic resonance logging applications and technical considerations when interpreting data. The talk was well attended.

DWLS April 2019 meeting. Marcus Donaldson (Mount Sopris Instruments) was the spoke speaker.

Upcoming Events

21 May 2019 –Alan Byrnes (Whiting Petroleum Corp) will be presenting a talk entited "Unconventional Core Analysis—What Do We Do 'Right', What Do We 'Misinterpret', and the Importance of Reference Frame (PVTxt)."



Alan P Byrnes (Whiting Petroleum Corp) will present his talk on unconventional core analysis on May 21 2019 at the Wynkoop Brewery.

22 October 2019 – DWLS will be cohosting a Fall Symposium with RMAG in Lakewood, Colorado. The theme of the symposium will be "Multiscale Imaging for Reservoir Optimization." The deadline for the Call for Papers is 22 April 2019. The technical program will focus on recent multidisciplinary reservoir studies, new interpretations of image analysis linked to production optimization and understanding, and new play concepts and prospects based on application of image analysis and petrophysics. Submit your abstract today online at the RMAG website or send to: kyared@sm-energy.com

JAPAN CHAPTER
(Japan Formation Evaluation Society, JFES)

General News

The JFES board members have recognized the paper by Yuto Sasaya (JAPEX), Yusuke Kumano (JAPEX), Isao Kurosawa (JOGMEC) titled, "Fracture Extension Behavior Dominated by Geologic Features of Pre-Existing Natural Fractures and Stress Barriers—An Interpretation of Microseismicity at the North Montney Unconventional Shale Gas Field, British Colombia," to receive the Best Presentation Award for the 2018 JFES Symposium. The award will be presented to the recepients at the upcoming 2019 JFES Symposium. The authors combined the techniques of microseismic, seismic attributes and logging data, to investigate fracture creation behavior in a shale gas field and its relationship between existing natural fractures. Geomechanical properties, such as Poisson's ratio and Young's modulus were adopted and the term "stress barrier" well-describes the cause of fracture creation blocked in the specific layers. Under the current situation in our industry, applying adequate operation to maximize recovery from existing fields is as important as finding new fields. This cannot be accomplished by understanding geological and geomechanical features in our field precisely.

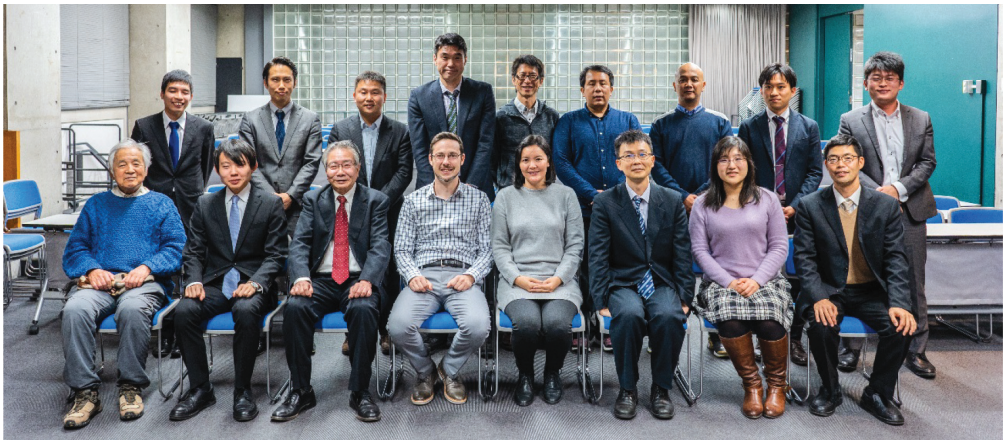
Mr. Takehiro Minawa, the previous first VP, transferred out of the country for his job. We would like to thank his work as first VP and wish his success in his new position oversea. Meanwhile, JFES welcomed Mr. Ryo Sakamoto to our board members as a new director. With a new board member, we are now working to prepare the annual symposium, which is to be held on September 2019.

JFES Board Members 2017–2019:

President	Masanori Kurihara
First Vice President	Tetsuya Yamamoto
VP Membership	Hideo Komatsu
Secretary	Yuki Maehara
Treasurer	Kunihiro Tsuchida
Directors	Takeo Aoyama, Tetsuzo Fukunari, Satoshi Hada, Takuya Ishibashi, Takayuki Kanno, Chisato Konishi, Tadahiro Nagano, Ryo Sakamoto, Shinichi Sakurai, Yoshinori Sanada, Tatsuya Sato, Aiko Takada, Tetsuya Tamagawa

Recent Events

17 December 2018 – The 2018 JFES Distinguished Lecture was held at Waseda University, Tokyo Japan. A total of 25 people from the various companies and universities attended in this event. It is good time to discuss petrophysical applications for thinly laminated shale-silt-sand formation evaluation with JFES members. Hideo Komatsu, JFES board member, gave an introduction on the general method of shaly sand formation in the oil and gas industry. The Distinguished Lecture titled "The Problem with Silt in Low Resistivity Low Contrast (LRLC) Pay Reservoirs," was presented by Alexander Belevich (Baker Hughes, a GE company).



JFES December 2018 meeting. Social hour after the distinguished lecture. Alexander and his wife (center) with JFES members.

14 March 2019 – The 107th Chapter Meeting was held at Schlumberger K.K., Tokyo Japan. A total of 39 people from the various companies and universities attended in this meeting and we discussed about the application of machine learning to petrophysical and borehole geology application for the carbon capture storage. There were two presentations: "Well Log Analysis with Class-Based Machine Learning for Petrophysics" by Yuki Maehara (Schlumberger), and "Borehole Image for Carbon Capture Storage Site Selection and Operation" by Somenath Kar (Schlumberger)

Upcoming Events

11 July 2019 – The 108th chapter meeting will be held at the JAMSTEC Tokyo office.

25–26 September 2019 – The 25th Formation Evaluation Symposium of Japan will be held at JOGMEC-TRC. The program details will be announced separately. Please feel free to join us!

Please visit https://jfes-spwla.org/ for more details.

KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS (KFUPM) STUDENT CHAPTER

General News

The SPWLA-KFUPM chapter was established in 2017 with 10 members. Since then, membership has increased three-fold. Student members include undergraduate and graduate students from the Department of Petroleum Engineering as well as the Geosciences Department.

The current executive committee comprises the following graduate students:

President	Amjed Hassan
Vice President	Muhammad Said
Executive Officers	Zeeshan Tariq
	Mohamed Elmuzafar
	Jaber Al-Jaberi
	Adedimeji Adeyemi
	Abdulmalek Ahmed

Recent Events

14 March 2019 – Dr. Hasan Kesserwan (Research Scientist at Baker Hughes Technology Centre, Dhahran Techno Valley) gave a lecture titled " Insights on Wellbore Instability—Use of NMR to Characterize Wettability and Pore Structure"

11 April 2019 – The chapter organized a special seminar with two guest speakers, Dr. Paul Connolly and Dr. Nicholas both from the University of Western Australia. Dr. Paul Connolly, a Research Fellow at the Fluid Science Research Division, School of Mechanical and Chemical Engineering, gave a lecture titled "Simulation of Experimental Measurements of Internal Magnetic Field Gradients and NMR Transverse Relaxation Times T_2 in Sandstone Rocks." Dr. Nicholas Ling, member of the Fluid Science and Resources Research Group, gave a lecture on "Applications of NMR Pulsed Field Gradient Techniques on Emulsions and Porous Media Studies.

Upcoming Events

The Chapter will conduct series of special seminars on topics related to petrophysics, formation evaluation, and rock characterization. Speakers from industry and academic fields will be invited.

More information is available on the Chapter website and Facebook page: https://www.linkedin.com/company/spwla-kfupm-student-chapter/
https://www.facebook.com/SPWLAKFUPM/

LONDON CHAPTER (London Petrophysical Society, LPS)

Recent Events

07 March 2019 – Our Petrophysics 101 seminar, co-organized with the PESBG YPs (Petroleum Exploration Society of Great Britain Young Professionals) was a great success with a series of talks on wide ranging topics, covering unconventionals, carbonates, thin beds and shaly sands. We had a great turn out and a very interactive session, with crowd polling for the first time at the LPS. Thanks to all of our speakers and attendees, and to the PESGB for helping to organize such a great day.

LPS One-Day Seminar March 2019.

16 April 2019 – Thanks very much to Alberto Ortiz (Principal Petrophysicist at YPF S.A.) for our most recent evening lecture. Alberto gave his SPWLA distinguished Speaker presentation on "What Have We Learned From Petrophysical Evaluation of the Vaca Muerta Formation During the Last Five Years of Unconventional Shale Play Exploration and Development?" We also had a great evening lecture by Alberto Mendoza of the Alan Turing Institute, on "Statistical Methods to Enable Practical On-Site Tomographic Imaging of Whole-Core Samples." It was a very interesting talk which sparked some good discussion and debate around core imaging issues. Thanks very much to Alberto, who gave his talk as part of the SPWLA distinguished speaker program.

Upcoming Events

21 May 2019 – Iulian N. Hulea (Senior Petrophysicist, Shell) will give the presentation at our next evening lecture on "Understanding Fundamental Controls of Hydrocarbon Saturation: From Stress Corrections to Perched Water Contacts." This will be held upstairs in the Council Room of the Geological Society, London.

MALAYSIA CHAPTER
(Formation Evaluation Society of Malaysia, FESM)

General News

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

Recent Events

27 March 2019 – May Sari Hendrawati (Petronas) delivered a talk entitled "Derisking a Complex and Mature Field Subsurface Development Plan Using Reservoir Flow Analysis and Pressure Pulse Code Testing." She explained how to resort the complex completion challenges via reservoir flow analysis (RFA) combined with a Pressure Pulse Code Test (PCT). The RFA results successfully identified water production, productive an unproductive hydrocarbon for each perforated sand layer. PCT confirmed the absence of a barrier between well injector and oil producer. As a result, 14.25 MMSTB was verified and avoided VOI well drilling, which result in the equivalent of RM50 million cost saving.

FESM March 2019 meeting. May Sari Hendrawati (Petronas) presenting.

THE NETHERLANDS CHAPTER
(Dutch Petrophysical Society, DPS)

Recent Events

11 March 2019 – Iulian Hulea (Shell) presented his talk on ''Understanding Fundaments Controls of Hydrocarbon Saturation: From Stress Corrections to Perched Water Contacts'' to a joint SPE Netherlands and DPS chapters meeting. In first part of the lecture; the origins, recognition and modeling concepts of perched water and their impact on recoverable reserves were discussed. The second part of the lecture discussed saturation-height models, the effect and applicability of stress corrections on capillary pressure data and their impact on saturation models. The audience engaged in lively discussion on both topics during, and after the talk. DPS would like to thank all attendances and a speaker for an inspiring session.

DPS March 2019 meeting. DPS Secretary Danijela Krizanic presenting Iulian Hulea with a token of appreciation from the SPE.

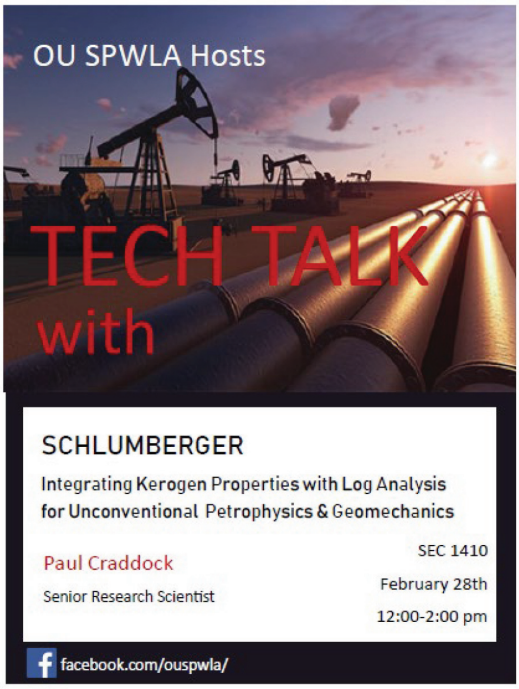
OKLAHOMA UNIVERSITY SPWLA STUDENT CHAPTER

General News

The chapter conducts one technical talk every month for the undergraduate and graduate students in the Mewbourne School of Petroleum and Geological Engineering (MPGE) department. The topics vary widely, encompassing innovative downhole logging tools, integrated petrophysics workflows, case studies, etc. The chapter currently has 101 student members.

Recent Events

28 February 2019 – The chapter was proud to host Paul Craddock (Schlumberger) for our spring tech talk. He gave his SPWLA Distinguished Speaker presentation on "Integrating Kerogen Properties with Log Analysis for Unconventional Petrophysics and Geomechanics."



08 March 2019 – The chapter organized a spring social event where professors and students interacted in informal settings. The spring social event was held at Fuzzy's on the campus corner, Norman.

09 April 2019 – We hosted Stefan Hertel (Shel) gave his SPWLA Distinguished Speaker presentation on "Upscaling of Digital Porosities by Correlation With Whole Core CT Scan Histograms."

QATAR CHAPTER

General News

We are based in Doha and welcome professionals and students interested in well logging and formation evaluation. The SPWLA Qatar Chapter promotes technical talks in close partnership with our sister and well-established Qatar SPE Section (QSPE).

Recently we had some changes to the QSPWLA committee. We say a goodbye and thank you to Magdy Samir (Schlumberger), Ahmed Mokhtar (Schlumberger) and Nayef Alyafei (TAMUQ University) for all their contribution. The updated committee is:

President	Sharon Finlay (NOC)
Vice-President	Calvin Myers (Qatargas)
Secretary	Jose Oliveira Neto (Qatar Shell)
Social Media Coordinator	Hussein Jichi (BHGE)
Registration & Mailing List	Faisal Abdulrahman Al-Mutawa (Qatargas)
Active Board Members	Ali Zwali (Halliburton)
	Enrique Diaz (BHGE)
	Ashok Srivastava (QP)
	Mauro Viandante (Schlumberger)
	Khaled Sassi (Sclumberger)
	Mohamed Fadlemula (TAMUQ).

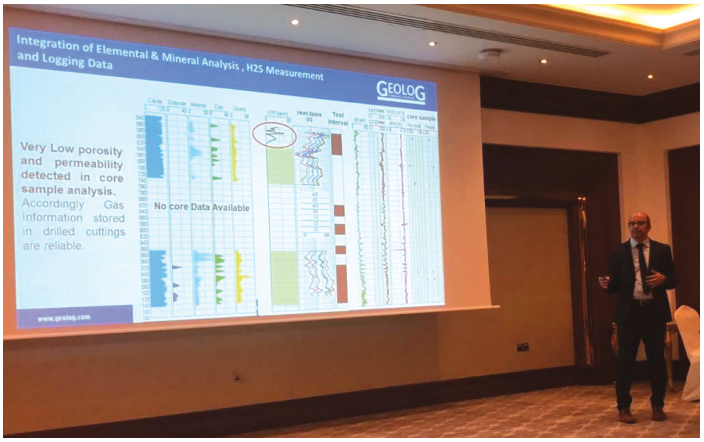
SPWLA Qatar February 2019 meeting. Part of the SPWLA Qatar Chapter Committee and the speaker: (left to right) Faisal, Enrique, Ashok, Sharon, Ali Zwali, Jose Oliveira Neto, Dzevat Omeragic (presenter), Mauro, and Calvin.

Recent Events

17 February 2019 – 2018–2019 SPWLA Distinguished Speaker Dzevat Omeragic (Scientific Advisor, Schlumberger) gave an interesting talk on "Towards 3D Reservoir Mapping Using Deep Directional Resistivity." The talk was well attended and presented several examples on the applications of geosteering and the modeling and inversion used during the job.

20 March 2019 – We held our first dual event, which consisted of an introductory session focusing on the basics of "Advanced Mud Logging" and its applications presented by Vincent Franzi (Formation Evaluation Specialist) followed by the technical talk titled "Advanced Mud Logging Technologies: A New Perspective for Fluid Characterization and Formation Evaluation" presented by Ahmad Shoeibi (Formation Evaluation Specialist). Both talks were kindly sponsored by GEOLOG International.

SPWLA Qatar March 2019 meeting. Audience listening to the introduction to advanced mud logging session.



SPWLA Qatar March 2019 meeting. Ahmad Shoeibi giving the technical talk and deepening the discussions on AML and its applications.

29 April 2019 – Antoine Elkadi (Geoscience Manager, TGT Diagnostics) gave a presentation on "True Flow Analysis With the Aid of Spectral Noise Logging and High Precision Temperature Modelling." This will be our last talk before the start of Ramadan (May) and the summer break! We will resume our activities in September!

In case you want to be added SPWLA Qatar Chapter mailing list, please email us at QSPWLA@gmail.com or talk to any of the committee member! We look forward meeting you!

Please remember: SPWLA Qatar Chapter in on LinkedIn! ☺ Follow us to stay updated about our chapter activities!

SAUDI ARABIA CHAPTER (SAC)

Recent Events

27 February 2019 – SPWLA Saudi Chapter (SAC) conducted its first technical luncheon of 2019. Marie Van Steene (Principal Petrophysicist, Schlumberger Wireline Saudi Arabia) presented a new technology for "Rigless Mineralogy Logging for Improved Geological Modeling and Reservoir Understanding." In the presentation, Marie demonstrated the capability of obtaining reservoir mineralogy from the newly developed slim pulsed-neutron logging run rigless in existing wells so that improved geological modeling and reservoir simulation are possible. This event was overbooked with more than 70 attendees.

SAC February 2019 meeting. Marie Van Steene delivering her technical talk.

13 March 2019 – Hans-Christian Freitag (BHGE VP of Geoscience and Petroleum Engineering) presented on a hot topic with "Big Data, Automation and Integration in the E&P Industry." Hans-Christian shared ideas on the importance of a deep understanding of the subsurface to validate output from machine learning and Big Data. This is where geoscience has an important role to play, integrating data from multiple sources and multiple disciplines into a model that accurately captures the intricacies of the subsurface, such that automation efforts and Digital Twins have a firm foundation in science and engineering. The presentation was well attended, with 90 plus participants of professionals and management.

SAC March 13, 2019 meeting. Hans-Christian Freitag delivered a talk on Big Data, Automation and Integration in the E&P Industry.

17 March 2019 – A technical presentation was given by Brian Hornby (Halliburton Chief Scientific Advisor) on the topic of "Achieving Business Value Using Borehole Sonic Data." Brian started with a brief history of sonic logging and then discussed ways to better understand the new breed of sonic data with simple observations and quality control. Extensive discussion on advancement in acoustic petrophysics was conducted during the Q&A.

SAC March 17, 2019 meeting. Brian Hornby presented a talk on sonic logging and acoustic petrophysics.

28 March 2019 – SAC conducted a technical seminar titled "Microseismic Event Location Using Direct and Reflected Waves" by Pierre-François Roux (BHGE Global Microseismic Advisor). In his talk, Pierre reviewed two important factors drive the precision of the hypocenters of the microseismic events; these are the quality of the modeled travel times and the effective aperture of the recording network. During the talk, he focused on improving the two aspects. First, by adding the reflected P-wave in the velocity model calibration and increased the constraints and avoid falling into secondary minima. And the second is to enhance the effective data-acquisition aperture for the location purpose. It was an interesting topic to broaden the knowledge of petrophysicists into the domain of geophysics.

SAC March 28, 2019 meeting. Speaker Pierre-François Roux receiving the speaker's gift in appreciation.

03 April 2019 – Vikas Jain (Global Domain Head for Petrophysics, Acoustics and Geomechanics for SIS Data Services of Schlumberger) gave a technical presentation entitled "From Machine Learning to Class-Based Machine Learning." Vikas discussed a novel approach along with examples of new answer products that include the automated spatial search for common modes and repeated patterns in the single and multiwell NMR logs. He also discussed the generation of a data-driven fluid model using time-lapse logging data acquired during multiple phases over the same formation and a workflow of class-based machine learning for well-data processing and interpretation with its applications associated results on various case studies.

TEXAS TECH UNIVERSITY SPWLA STUDENT CHAPTER

General News

The elected officers for the 2018–19 academic year are:

President	Daniel Owusu-Ansah
Vice President	Ibe Ezisi
Treasurer	Elizabeth Reeder
Membership Chair	Rushil Pandya
Secretary	Garrett Payne
SORC Representative	Kristofer Aasen

Recent Events

25 February 2019 –We hosted a joint event with the other organizations in the TTU Petroleum Engineering Department: American Rock Mechanics Association (ARMA), American Association of Drilling Engineers (AADE), Ladies in Petroleum (LIP), and Society of Petroleum Engineers (SPE). This event had special guest speaker Mrs. Linda Swindling; a professional speaker and author gave a talk on how to negotiate for job offers, raises, and promotions. This event was great for the students to gain vital knowledge for their futures in the work force and how to be prepared for the corporate world.

SAC April 3, 2019 meeting. Vikas Jain delivered (center left) delivered the technical talk.

TTU February 2019 meeting. Mrs. Swindling addressing the students.

TTU March 21, 2019 paper competition. Contestants Edwyn, Aman, and Rushil.

TTU February 2019 meeting. TTU PE organization officers after gift presentation to the speaker Linda Swindling.

Judges: Dr. Henderson, Dr. Asquith, Mr. Newsham, and Mr. Williams.

21 March 2019 – We conducted the chapter's 2019 student paper contest. We had four judges: two internal judges (petrophysics professors from TTU: Dr. Steven Henderson and Dr. George Asquith) and two external judges (Senior Petrophysicists from industry: Mr. Kent Newsham and Mr. Akinlolu Williams).

We had three contestants: Aman Arora (First place), Rushil Pandya (Second place), and Edwyn Bougre (Third place). They were awarded cash prizes in the amount of $1,000, $750 and $500, respectively. Their work was judged on the basis of technical content, presentation skills/delivery, quality of slides/materials, and timeliness. We hope that all three contestants will be representing Texas Tech University at the upcoming SPWLA International student paper competition on June 16, 2019, in the Woodlands, Texas.

22 March 2019 – The following day, we had the honor of hosting Mr. Newsham once more for our first monthly meeting of the semester. The topic of his discussion was the third part of his previous talk from last semester, a novel workflow of estimating storage and flow capacity in mudstones.

We have been fortunate to build a relationship with Mr. Newsham and Occidental Petroleum Company (Oxy) and are very grateful for how he has helped our organization. Through Mr. Newsham's help, our organization gained sponsorship in the amount of $2,000 from Oxy to attend the SPWLA symposium in June of this year.

TTU March 22, 2019 meeting. Students (left) and faculty (right) presenting Mr. Newsham with gifts in recognition of his contributions to the Chapter.

29–30 March 2019 – The Chapter hosted a two-day software training course on Schlumberger's Techlog software. We had the privilege of hosting five Schlumberger technical experts to train some of our students. Being exposed to a highly used software for petrophysics and well log analysis was a great learning experience for our students.

TTU March 2019 software training seminar.

16 April 2019 – Election of 2019–2020 Officers was held.

UNIVERSIDADE FEDERAL DO RIO DE JANEIRO (UFRJ) STUDENT CHAPTER

General News

We're organizing the 3rd Petroleum Geology Week (SEGEP), along with the UFRJ AAPG Student Chapter. Other activities include internal meetings and video calls with other chapters around the world to exchange experiences;

Recent Events

11 April 2019 – Presentation of the student chapters for freshmen, organized by UFRJ SPWLA, AAPG and SEG Student Chapters

16 April 2019 – SPWLA Brazil Meeting

SPWLA UFRJ April 2019 presentation for the freshman

UNIVERSITY OF HOUSTON STUDENT CHAPTER

Recent Events

02 March 2019 – UH Engineering College new student orientation. UH President Charles Adams, Treasurer Sara Zarioui and Faculty Advisor Professor Lori Hathon greeted prospective UH Petroleum Engineering students at the main campus' engineering building. We encountered over one dozen prospective students, along with their parents/siblings and entertained any and all questions they had concerning our college. After lunch, we accompanied these students and family members on a bus to the Energy Research Park (Building 9) where a building tour was conducted including two research labs. Afterward, we returned them to the main campus and escorted them to the next stage of their UH orientation tours.

SPWLA UH new student orientation: From left: Chapter Treasurer Sara Zarioui and Professor Lori Hathon (Faculty Advisor).

14 March 2019 – A well logging help session was conducted over Spring break in order to teach Professor Hathon's students the necessary midterm subjects they'd face upon their regular session return. Subjects included permeability logs, porosity logs, resistivity logs, crossplotting procedures, obtaining R_w from the SP log and obtaining R_t, R_{xo} and diameter of invasion from a tornado chart.

18 March 2019 – a petrophysics help session was conducted to assist Professor Mike Myer's students with the subjects they'd face on their midterm exam. Subjects included Darcy's law, gas flow, capillary pressure curves and their calculated depths through differing reservoir layers and Hagen-Poiseuille's law.

23 March 2019 – the SPWLA UH Chapter conducted a Student Paper Contest in accordance with the International "Call for Abstracts." For the third year in a row the hard work of our officers and faculty advisors enbled UH to have finalists in the International competition (Master's and PhD categories).

SPWLA UH Student Paper Contest March 2019. Contestants (left to right): Sabya Prakash, Abdullah Bilal, Naveen Krishnaraj, Nicolas Juarez Rausseo and Charles White.

SPWLA UH Student Paper Contest March 2019. PhD category Winner/ Finalist Abdullah Bilal (left) with SPWLA UH President Charles Adams.

SPWLA UH Student Paper Contest March 2019. Masters Winner/Finalist Sabya Prakash (right) with SPWLA UH President Charles Adams.

06 April 2019 – Chapter President Charles Adams and Treasurer Farnaz Yazdani greeted next semester's Petroleum Engineering students and their families answering questions they had regarding our college. As with the previous orientation, we accompanied the students and family members on a bus to the Energy Research Park (Building 9) where a building tour was conducted including two research labs. Afterward, we returned them to the main campus and escorted them to the next stage of their UH orientation tours.

SPWLA UH April 2019 petroleum engineering student orientation. SPWLA UH President Charles Adams (left) and Chapter Secretary Farnaz Yazdani (right).

THE UNIVERSITY OF TEXAS AT AUSTIN STUDENT CHAPTER

General News

As we reach the end of our activities of the 2018–2019 academic year, we would like to express our gratitude to:

- All the speakers that dedicated their valuable time coming to Austin;
- Our chapter adviser Dr. Carlos Torres-Verdin for his guidance in all our activities;
- Many SPWLA board members and officers who helped us throughout the year;
- The SPWLA Houston Chapter, Marathon Oil Corporation, Shell E&P Company, and Schlumberger-Doll Research for the financial support;
- And all the volunteers that made our events possible.

Our student chapter has been very active in hosting technical talks, meetings, and participating in volunteering activities. We would also like to invite y'all to check out our activities on our LinkedIn page or on our Facebook page:
https://www.linkedin.com/company/student-chapter-of-spwla-at-ut-austin/
https://www.facebook.com/SpwlaAustinChapter/

Recent Events

21 February 2019 – The chapter hosted Dr. Carl Fredrik Berg from the Norwegian University of Science and Technology (NTNU) for a technical presentation titled "Pore-Scale Imaging and Simulation".

SPWLA UT February 2019 meeting. Officers of the Chapter with Dr. Carl Fredrik Berg from the Norwegian University of Science and Technology (NTNU). Pictured from left to right: Tianqi Deng (Secretary), Andres Gonzalez (Social Media Coordinator), Carl Fredrik Berg (Speaker), Mohamed Bennis (Vice-President), Artur Posenato Garcia (President), and Richard Jiang (Public Relations).

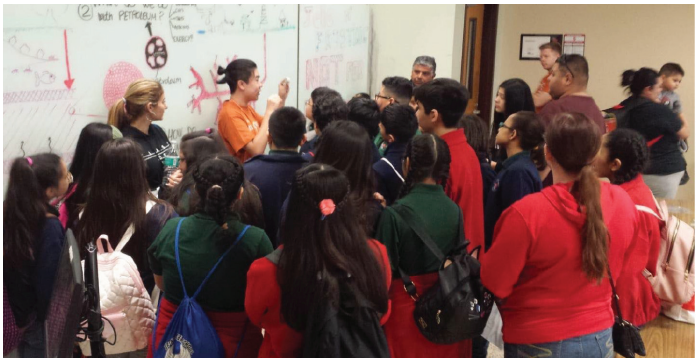
23 February 2019 – Chapter members partnered with the Petroleum Graduate Student Association to participate in "Introduce a Girl to Engineering Day" at The University of Texas at Austin. Over 8,700 elementary and middle school students participated in the event, which gave them a chance to explore careers in science, technology, engineering, and mathematics. The Student Chapter of SPWLA at UT-Austin led a hands-on activity, titled "Fracking with Jell-O," for approximately 400 kindergarten through 8th grade students. This event provided an excellent opportunity for our chapter to give back to the community while sharing our passion for engineering and geosciences with young students from across Texas.

SPWLA UT February 2019" Introduce a Girl to Engineering Day."

01 March 2019 – the chapter hosted SPWLA Distingjuished Speaker Dr. Paul Craddock (Schlumberger-Doll Research Center) for a technical seminar titled "Integrating Kerogen Properties with Log Analysis for Unconventional Petrophysics and Geomechanics." Approximately 50 students attended this excellent presentation.

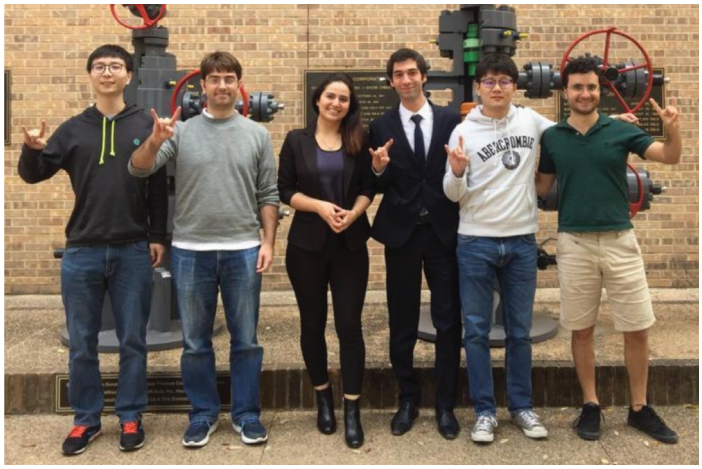
SPWLA UT March 1, 2019 meeting. Chapter officers with Dr. Paul Craddock (Schlumberger-Doll Research Center). Pictured from left to right: Mohamed Bennis (Vice-President), Tianqi Deng (Secretary), Paul Craddock (Speaker), Sebastian Ramiro (Treasurer), and Artur Posenato Garcia (President).

02 March 2019 – Chapter members partnered with the Petroleum Graduate Student Association to volunteer at "Explore UT" at The University of Texas at Austin. This annual campus-wide event, which is described as the "Biggest Open House in Texas," seeks to broaden the horizons of students in Texas, particularly those from under-represented groups, and motivate them to pursue higher education after high school. Once again, the Student Chapter of SPWLA at UT-Austin led a hands-on activity, titled "Fracking with Jell-O," for approximately 400 kindergarten through 12th grade students.



SPWLA UT March 2, 2019. The Chapter partnered with the Petroleum Graduate Student Association to volunteer at "2019 Explore UT" at The University of Texas at Austin.

15 March 2019 – The chapter held a local student paper contest to nominate members for the 2019 SPWLA Student Paper Contest in Woodlands. We would like to congratulate Gulcan Bahar Koparal and Sercan Gül for winning 1st places in the master's and PhD divisions, respectively. We hope that this year's local winners can continue the outstanding success achieved at last year's annual symposium in London where our members won 1st place in the Bachelor's and PhD divisions!

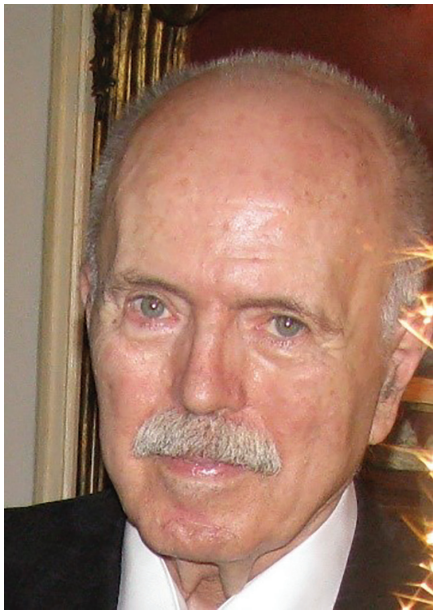


SPWLA UT March 2019. Officers of the Chapter with the winners of the SPWLA Student Paper Contest at UT Austin. Pictured from left to right: Wen Pan (Webmaster), Artur Posenato Garcia (President), Gulcan Bahar Koparal (1st place in the master's division), Sercan Gül (1st place in the PhD division), Tianqi Deng (Secretary), and Mohamed Bennis (Vice-President).

12 April 2019 – The chapter hosted a technical seminar by SPWLA Distinguished Speaker Dr. Stefan Hertel (Shell International Exploration and Production Inc.) titled "Upscaling of Digital Porosities by Correlation with Core CT Scan Histograms." The talk was very well attended.

SPWLA UT April 2019 meeting. Officers of the Student Chapter of SPWLA at UT-Austin with Dr. Stefan Hertel (Shell International Exploration and Production Inc.). Pictured from left to right: Artur Posenato Garcia (President), Wen Pan (Webmaster), Stefan Hertel (Speaker), Sebastian Ramiro (Treasurer), Mohamed Bennis (Vice-President), and Tianqi Deng (Secretary).

Christian Clavier
1928–2019



Christian Clavier passed away on January 31st at age 91.

It is difficult to write a eulogy about a legend. In the 1950s and 1960s, Christian was nicknamed *el hombre con siete cabezas*, the man with seven heads. So, some research about real facts beyond the myth is needed.

Christian graduated from Ecole Centrale de Paris, the same education organization as Gustave Eiffel and Marcel Schlumberger, in 1952. He then pursued a degree in geology at the University of Fribourg, Switzerland under the guidance of Professor Jean Tercier, an eminent geologist.

Before then, as a teenager, he had met the love of his life, Madeleine, a widow with four children, whom he called Poupette with *tendresse*. At this point, he decided to enter a career in the oil industry where he would be able to provide elegantly for her and for her progeny.

He started with Schlumberger as a field engineer in the oilfields of North Africa, Southeast Asia, and then Western Australia. There, he developed an intimate understanding of what is happening in wells and about field reality. He then moved to interpretation development and research in several locations, in South America, Paris, and Ridgefield, Connecticut. His interests were 360° around: Formation testing, gas detection with neutron logging, cement-bond log interpretation, gradiomanometer in diphasic flows, pyritic formations, dipmeter information, etc...

The peak of his research was to fully understand shaly sands, not in an empirical way, as some others did, but with real physics. The Dual-Water Model, still in much use today, was his creation. He was awarded the SPWLA Gold Medal for Technical Achievement in 1988.

In the meantime, the Christian Clavier award was initiated by his employer to honor outstanding contributions to technique and innovation.

Later, Christian used his futuristic vision to investigate many topics. He made plans for strategies in data processing as early as the late 1970s. He then envisioned that high-deviation/horizontal drilling would become the common production scheme in the early 1990s. A few weeks before leaving us, he was brainstorming about solutions on global warming.

He was the man you could call or contact for any formation evaluation question and he would answer with a disarming clarity.

In addition, Christian and Poupette generously donated several of her paintings to be auctioned in order to bring funds to the SPWLA foundation that distributes grants and scholarships to students dedicated to the science and art of petrophysics.

I expect that I am not alone now in feeling like an orphan. Christian trained so many people and shared his wisdom and humanity with humility and generosity.

Philippe Theys

Note: Sophie de Acosta (daughter), Stefan Luthi, Henry Edmundson and Mark Mau contributed details to this text as well as photos.

Kittisupalauk, Sutasinee, PTTEP, Chatuchak, Bangkok, Thailand
Vianna, Armando, Baker Hughes a GE Company, Kuala Lumpur, Malaysia
Ortiz, Nereida, Schlumberger, Houston, TX, United States
Colgan, Gene, Silverback Exploration Ii, Katy, TX, United States
Genssler, Klaus, ExxonMobil, Spring, TX, United States
Bandyopadhyay, Parthasarathi, PTTEP, Bangkok, Thailand,
Molina, Jose, Petro Data Integration, Denver, CO, United States
Popov, Alexey, DeGolyer and MacNaughton, Moscow, Russian Federation
Sorokina, Ekaterina, DeGolyer and MacNaughton, Moscow, Russian Federation
Sarkar, Debashish, Fern Geophysics, Edmond, OK, United States
Harnondo, Ratno, Santos Ltd, Adelaide, SA, Australia
Steele, Matthew, Halliburton, Saint Martinville, LA, United States
Espinola, Bernardo, Petromac, Queretaro, Mexico
Khalil, Hassan, Baker Hughes a GE Company, Houston, TX, United States
Farouq Ali, Syed, University Of Houston, Houston, TX, United States
Li, Jian, Halliburton, Houston, TX, United States
Lee, Gordon, Paramount Resources Ltd., Airdrie, AB, Canada
Kitchener, Steve, Repsol Sinopec , Inverurie, Aberdeenshire, United Kingdom
Mccormick, Stephen, Petromac Ltd, Auckland, New Zealand
Yenugu, Malleswar, IHS Markit, Houston, TX, United States
Whitby, Bryan, Raptor Consulting Inc, Bridgeville, PA, United States
Wibowo, Vera, Schlumberger, Sugar Land, TX, United States
Meyer, Thomas, Signum Instruments, Houston, TX, United States
Thatha, Rajesh, Petromac Limited, Dubai, United Arab Emirates,
Amadi, Kelechi, Government Of Saskatchewan, Regina, Canada,
Hinkle, Ana, Baker Hughes a GE Company, Katy, TX, United States
Rabinovich, Vladimir, Tricon Geophysics, Cypress, TX, United States
Macdonald, Halli, Baker Hughes a GE Company, Houston, TX, United States
Fisher, Jim, Siemens, Greenville, SC, United States
Shrivastava, Chandramani, Schlumberger, Sugar Land, TX, United States
Zamani Farahani, Ramin, ConocoPhillips Canada, Calgary, AB, Canada
Carpio, Gustavo, Halliburton, The Woodlands, TX, United States
Herrera, Juan, Schlumberger, Sugar Land, TX, United States
Caviglia, Maria, Pan American Energy, Buenos Aires Argentina
Foito, Juelma, Total, Pau, Pyrenees Atlant, France
Pierre, Andal, Baker Hughes a GE Company, Houston, TX, United States
Zeroug, Smaine, Schlumberger, Cambridge, MA, United States
Terentyev, Sergey, Baker Hughes a GE Company, Houston, TX, United States
Qin, Jiasheng, Weatherford, Houston, TX, United States
Hughes, Harold, Fracture ID, Kingwood, TX, United States
Lebedev, Sergey, Adaga Solutions Ltd., Calgary, AB, Canada
Reyes, Allan, Schlumberger, Katy, TX, United States
Rossi, Apoena, Petrobras, Rio Das Ostras, RJ, Brazil
Tjugen, Ole, Equinor, Bergen, Norway
Uvarov, Igor, Rogii Inc., Houston, TX, United States
Wessling, Stefan, BHGE, Celle, Germany,
Hooten, Jessie, Denbury Resources Llc, Plano, TX, United States
Fedorov, Stanislav, Luxoft, Spring, TX, United States
Krause, Thorsten, One&Zero Ltd., Hamburg, Germany
Secrest, Stephen, Petrolegacy Energy Ii, Austin, TX, United States
Uzzo, Pablo, Tecpetrol, Buenos Aires, Argentina
Hayes, Martin, Stanfield Consultants Ltd., Ely, United Kingdom
Salehi, Mohammad Taghi, Schlumberger, Montpellier, France
Matyas, Janos, Dana Gas, Veresegyhaz, Pest Megye, Hungary
Brown, Daniel, Tulsa, OK, United States
Chohan, Mohammad, BHGE, Houston, TX, United States
Kalu, Innocent, Oilfield Production Consultants, Doha, Qatar
Turner, Jennifer, SNP Geological Consulting, Victoria, BC, Canada
Devine, Paul, Resource Analytics, Llc, Denver, CO, United States
Yang, Ming, Total, Pau, Aquitaine, France
Wang, Xingming, Chengdu, Sichuan, China
Qi, Qiaomu, Chengdu University Technology, Chengdu, Chenghua, China
Sakai, Hiroaki, Waseda University, Tokyo, Japan
Abdollahikhalili, Emadoddin, Curtin University, Como, WA, Australia
Turney, Bryce, University Of Louisiana at Lafayette, Duson, LA, United States
Yeo, Lenissongui, University Of Louisiana at Lafayette, Lafayette, LA, United States
Rivera, Eric, University Of Louisiana at Lafayette, Odessa, FL, United States
Jian, Zhao, China University Of Petroleum Beijing, Beijing, China
Onifade, Oluwakemisola, Federal University Of Technology, Akure, Lagos, Nigeria
Arengas Sanguino, Carlos, UIS, Bucaramanga, Santander, Colombia
Hellal Porras, LUIS, UIS, Bucaramanga, Santander, Colombia
Ma, Xuerui, China University Of Petroleum Beijing, Beijing, Changping, China
Sosa Hernández, Andrés, UIS, Bucaramanga, Santander, Colombia
Talero Montaña, Geraldine, UIS, Bucaramanga, Santander, Colombia
Tarazona Robles, Angela, UIS, Bucaramanga, Santander, Colombia

Welcome New Members—February 15, 2019–April 14, 2019

Abdelaziz, Aser, Agiba Petroleum Co., Cairo, Nasr City, Egypt
Mendez, Mirka, UT Austin, Austin, TX, United States
Hashmi, Gibran, Texas A&M University, Houston, TX, United States
Tugan, Murat, Texas A&M University, College Station, TX, United States
Gomaa, Ibrahim, King Fahd University, Dhahran, Saudi Arabia
Chawshin, Kurdistan, NTNU, Trondheim, Norway
Lonsdale-Lowther, Oliver, University Of Leicester, Kingsland, Herefordshire, United Kingdom
Torres, Veronica, NTNU, Trondheim, Norway
Ahmadov, Jamal, University Of Louisiana at Lafayette, Lafayette, LA, United States
Millen, Max, Queensland University of Technology, Brisbane, QLD, Australia
Depriest, Keegan, Southern Illinois University, Carbondale, IL, United States
Kamruzzaman, Asm, Colorado School Of Mines, Golden, CO, United States
Edell, Joseph, University Of Texas, Arlington, VA, United States
Guerrero Arrieta, Javier, UIS, Bucaramanga, Santander, Colombia
Mounited Stateslli Diaz, Victoria, UIS, Bucaramanga, Santander, Colombia
Parra, Edgard, New Mexico Institute of Mining and Technology, Socorro, NM, United States
Rios Pérez, Vanessa, UIS, Bucaramanga, Santander, Colombia
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