ISSUE 4 | VOL 2 | JULY 2019

THE SPWLA TODAY NEWSLETTER

60th Anniversary • 1959–2019

SOCIETY OF PETROPHYSICISTS AND WELL LOG ANALYSTS

INSIDE THIS EDITION

The Society of Petrophysicists and Well Log Analysts Board of Directors 2019–2020

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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

September 16–19, 2019
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
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

June 20–24, 2020
SPWLA 61st Annual Symposium
Banff, Alberta, Canada
www.spwla.org

About the Cover

See the 60th Annual Logging Symposium summary on page 18.

From the President

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

I'd like to start my first column as the 2019–2020 SPWLA President by acknowledging the previous Board of Directors (BOD) and their contribution during the past 12 months. Not only I recognize my predecessor, Zhipeng Liu and his Board, but also the past presidents who dedicated countless hours of work and have passed the baton year after year with projects that continue today. So, when you see Brett Wendt, Luis Quintero, Thaimar Ramirez, David Kennedy, and other past presidents please say thank you for their selfless contribution to the SPWLA over the last decade.

This year starts with a BOD that is no longer Houston-centered as many people used to say. I'll be working with a group of talented people hailing from Australia, Europe, the Middle East and the Americas. We have five newcomers serving for the first time on the board and seven returning veterans who will help me steer this vessel in turbulent and calm waters. Take a look at the map below showing where each BOD member is based around the world, I couldn't have asked for a more diverse group of professionals.

Fig. 1—Work locations of the Board of Directors. Only two Board members live in Houston!

The 2019 SPWLA Symposium, held at The Woodlands, Texas, was an absolute success. At the moment of writing these lines, the unofficial count of attendees surpassed 800, which was 30 to 40% above our expectations. This wouldn't have been possible without the leadership of the general chairman Jeff Crawford and his group of volunteers in the organizing committee, the VP Technology, Jim Hemingway, and his technical committee, and VP IT Mehrnoosh Saneifar who managed the last-minute changes in schedule from the Symposium app.

If you attended the Symposium you may remember Jeff walking the two floors and the exhibits over and over, he walked 8 to 10 miles a day making sure that everything went smoothly. But remember that no Symposium can happen without the two powerful engines of the Society, Executive Director Sharon Johnson and Stephanie Turner. My appreciation goes to all these volunteers, exhibitors, and authors that worked so hard to bring you a great show. I know that there were minor issues with AV and the eposter area wasn't great. However, we hope that you enjoyed the parallel sessions that we tried for the first time, opening opportunities for a more relaxed schedules and 12 additional oral presentations.

Fig. 2—2019–2020 SPWLA Board of Directors. From left to right, Jim Hemingway, Katerina Yared, Thomas Neville, Jennifer Market, Adam Haecker, Nadege Bize-Forest, Michael O'Keefe, Jesús M. Salazar, Kelly Skuce, and Lin Liang. Not in the picture: Doug Patterson, Mark Ma, and Craig Lindsay. Photo by Sharon Johnson.

We take your feedback very seriously and during the Symposium we ran several surveys in the app. The sample was not great, only 35 to 40 people responded to the survey. However, I still feel very happy with the results and I'm sharing them with you in the next figure. Based on this survey I believe we got a B in technical quality, we strive to select excellent abstracts, but remember that the papers are not peer-reviewed. However, having close to 30% above an 8 rating it's an indication that there were high-quality papers. Attendees seemed to be happy with the parallel sessions, prefer the new anonymous abstract review format, and were very happy with the smart-phone app.

My last project as President-Elect was to form and lead an ad hoc committee to update SPWLA's by-laws and chapters of incorporation. This team was formed by fellow BOD members, Katerina Yared, Carlos Torres-Verdin, and Adam Haecker. We focused our attention on a variety of topics, such as ethics, awards, elections, and the creation of a new permanent committee on social media. The proposed changes were reviewed by the president, a past president, and finally by a lawyer. We're still working on the final touches before sending it to the membership for approval. The idea is to have members vote on each proposed change individually. Expect an email in late summer requesting your vote, please cast a ballot. Another project completed in my last post was to get the Symposium papers included into the Scopus database (world's largest abstract and citation database). To make this possible, we applied and were granted the assignment of the ISSN number to the *SPWLA Symposium Transactions* by the Library of Congress. The objective is to increase citations of our publications (*Petrophysics* is already included) to encourage industry professionals and researchers to continue writing for the SPWLA. I plan to continue working with the Board to keep improving the quality and prestige of the SPWLA publications. Finally, I visited the University of Houston Student Chapter on April 26. I presented a quick overview of the SPWLA mission, benefits to membership, and progress during the last couple of years followed by a technical talk on source-rock petrophysics. I want to thank the University of Houston Student Chapter President, Charles Adams, and Professor Lori Hathon for the invitation.

Commodity prices keep fluctuating, sometimes giving us heartburn. However, these days there are opportunities for jobs. At the SPWLA we will try to reach out to members in transition every time we see an opening. But remember, "out sight out of mind," be visible. It is an exciting time to be involved with the SPWLA, I encourage everyone to volunteer, especially those young professional (YP) who are early on their careers. It's a great opportunity to network and learn from your more veteran peers how to standout and find that next career opportunity. Start with your local chapter, or reach out to any of the Directors and ask about volunteering options.

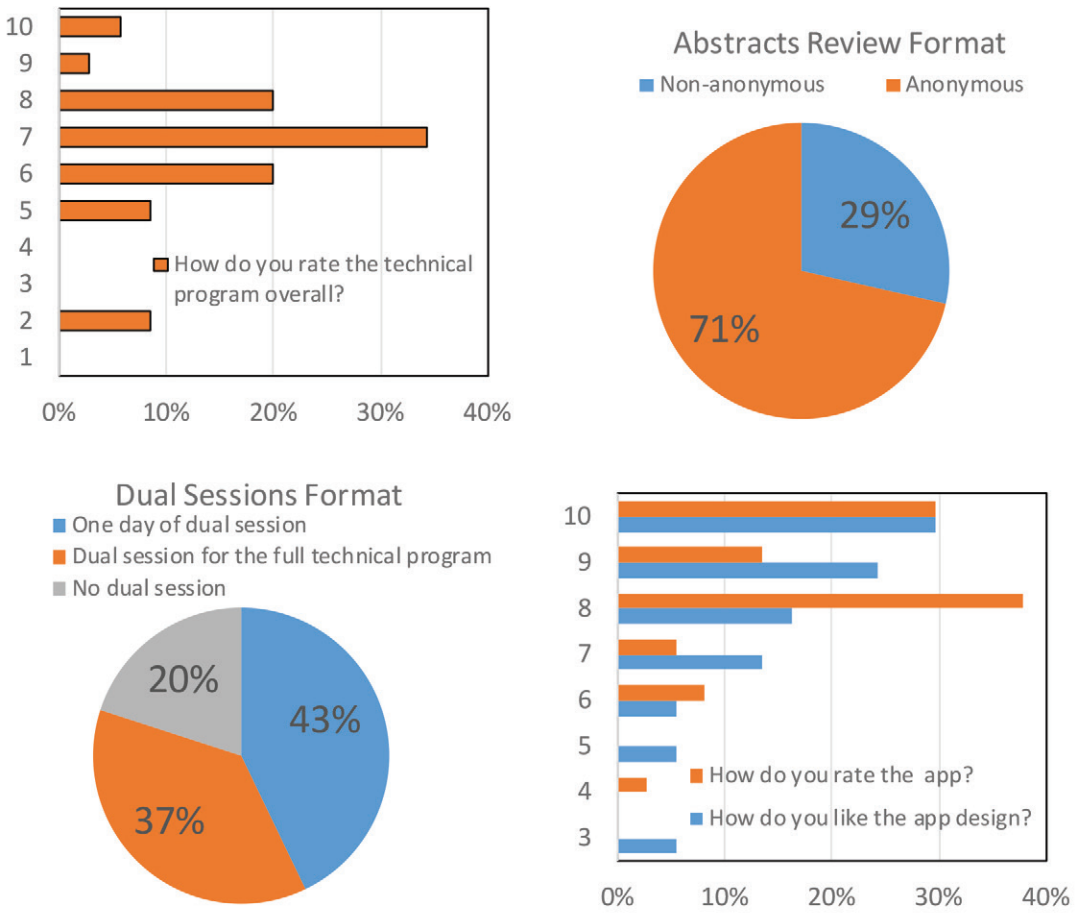
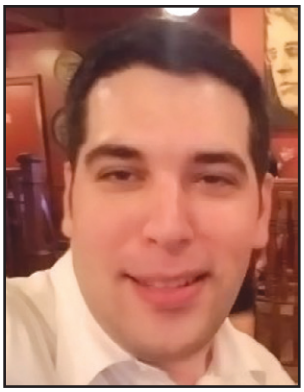


Fig. 3—Live surveys from the Symposium App, 10 is excellent and 1 is very poor. 100% thought that we must continue using the app in future Symposia. The survey was only available to Symposium attendees using the app.

Fig.4—Receiving the speaker's gift from Student Chapter President Charles Adam (right) with Professors Mike Myers (left) and Lori Hathon after my presentation at the University of Houston Student Chapter. Photo by Rossy Salazar.

I live in the Houston and plan on attending a few local seminars and also the social activities organized by the SPWLA YP Group, which are always open to anyone interested in rocks, fluids, and wiggles. It is my plan to get closer to the membership by visiting chapter and championing the creation of new SIG and professional and student chapters. I'm planning on keeping you informed of all the BOD activities via this magazine, social media, and regular email. Also remember, that my email and social media channels are available for any comments and suggestions anyone would like to make to improve the SPWLA. I don't promise to implement all of them, but for sure will bring them to the board.

Sincerely,
Jesús M. Salazar
linkedin.com/in/spwla-socialmedia-454464105
Instagram @chichosalazarpetro



Adam Haecker
NA Director 1

Another Symposium Concluded and What a Symposium It Was!!

As I write this I have just returned from the Woodlands and the 60th Annual Symposium. It was great seeing all colleagues old and new there. I noticed there were quite a few of our more seasoned members who have made contributions to the society for over 40 years in attendance. I attribute this to the fact that they likely did not have to travel very far to make the conference. One gentleman even got up to quip, "I need to come to these conferences more since I published this exact paper in 1972!" Much to the chagrin of the audience and the consternation of the presenter. I glanced over to see Roland Chemali, our esteemed past president, was almost rolling in the aisles after that one.

The social scene was vibrant as always. Definite highlight of the week for me was going to the Goose Acres bar next to the hotel with three of my Oklahoma City colleagues and chancing upon a table of about 20 petros. The Aussies were already pissed, as you might expect, and the rest of us soon followed. A good time was had by all. Earlier that same night we had attended what is probably the most French party I have ever been invited to. There were laser light shows and people on stilts. Most people seemed too intimidated to hit the dance floor but one our fearless colleagues decided to cut a rug with one of the dancers. Email me with who you think it might be! Here is the picture below and to the left of this. Hint: He resides near Denver.

Additionally, we installed the new board. I am excited for the coming year. Many of the new board members have good ideas that will benefit the society. Here are some pictures of the new Board that have already gone viral thanks to Katarina's prodigious LinkedIn following. Your new board is already hard at work—following the conclusion of the symposium we stayed till 9 pm Wednesday night—after everyone else had headed to the airport to get things rolling for next year. Things that were discussed include: changes to *SPWLA Today*; a new bonus system for the Staff; plans for the new technical committee and whether we want to have parallel sessions next year; when to hold board meetings; and proposed changes to the website. As always if you have ideas for the aforementioned topics please let us know.

I would like to give my picks for most interesting talks at the conference. I did not catch every single oral presentation or very many of the posters so there are likely many more excellent talks. However, these presentations stood out. Please keep in mind I mostly work in unconventional plays and that is usually my focus. If you only read a few papers and work on US land, check these out!

My picks for best papers of the symposium:

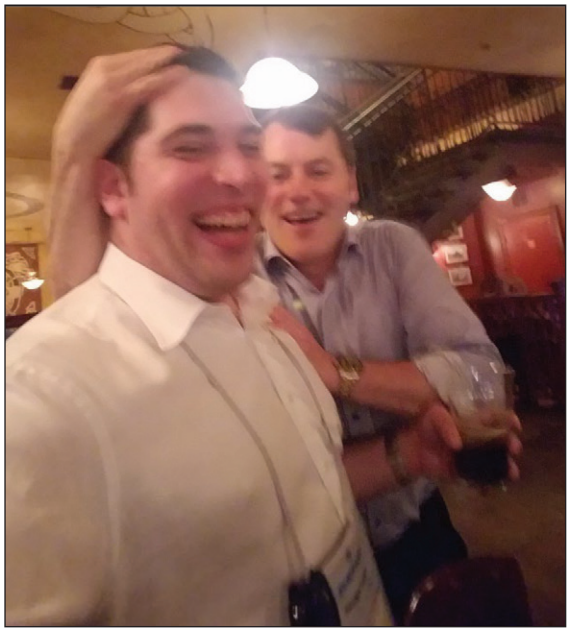
- Paul Craddock et al. (Paper JJJ) – "Thermal Maturity Adjusted Log Interpretation (TMALI) in Organic Shale."
- Melanie Durand et al. (Paper AAAA) – "Crushed Rock Analysis Workflow Based on Advanced Fluid Characterization for Improved Interpretation of Acquired Core Data" (GRI+).
- Nigel Clegg et al. (Paper HHH) – "The Final Piece of the Puzzle, 3-D inversion of Ultra-Deep Azimuthal Resistivity LWD Data."
- Gong Li Wang et al. (Paper PP) – "Determining Resistivity and Low Frequency Dielectric Constant Using Induction Data in the Presence of Strong Induced Polarization."
- Claudia Amorocho et al. (Paper Y) – "Improving Production in Child Wells by Identifying Fractures With an LWD Ultrasonic Imager: A Case Study From an Unconventional Shale I the U.S."
- Andres Gonzales et al. (Paper KKK) – Reliable Measurement of Saturation-Dependent Relative Permeability in Tight Rock Samples."

Regional Understandings – North America 1

What did everyone think of the parallel sessions at the Symposium? It was viewed as a compromise since the vote for and against is almost always split right down the middle. Personally, I prefer to see every talk so I can ask lots of questions. I actually asked the first and last question at this symposium. Both of which were to Dr. Carlos Torres-Verdin's students. I think he wanted me to sit down, LOL. But I digress, If you have strong feelings about whether we need more or less parallel sessions please contact our new VP of Technology Michael O'Keefe. Without your feedback the board will just do whatever we want. (We might do that anyway!)

Personally, I am excited for the new season of talks that will start in the fall. The Tulsa chapter is starting up its meetings again in September. Emails should go out in a month or two inviting folks to those talks. If you want free parking please RSVP. Also, please support your local chapters by attending talks if you are able to.

Finally, as is now an annual tradition. I must share my blurry pics of Paul Craddock. This year with the talented and brilliant Abbie V. Morgan. It's actually not that blurry this year. Some of you who are regular readers may remember I posted a picture with Paul and a Ham Eater from the Tower of London Last year.



Because I get unlimited pages here are a few more pics of the crew at Goose Acres.

Regional Understandings – North America 2

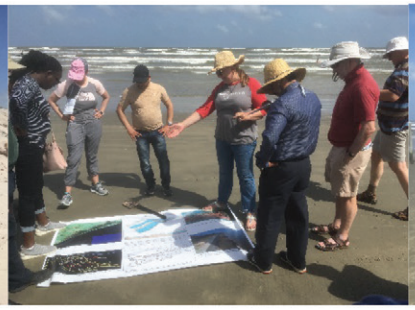
Kelly Skuce
North America Director 2

Hi, and welcome to my first column for the SPWLA Today newsletter. Thanks to all the SPWLA members who voted for me, I am very humbled to have been elected to represent them for the next two years.

I had a great time down in Texas at the SPWLA Symposium, on the field trip checking out the Brazos River delta, meeting old and new colleagues and enjoying the weather and sights of the Houston area.

As a geologist, I always try to get out and look at reservoir analogs in the modern (my family appreciates the beaches) and the ancient setting (they do not appreciate the roadcuts). The field trip to the historic and modern Brazos River delta was informative and enjoyable with good weather and great instruction from Dr. Julia Smith-Wellner of the University of Houston.

Beach dune with 1992 flood debris



Looking at maps on the beach

Partial group shot of attendees

Torrential downpour on Sunday night in Woodlands

Jays beat the Astros 12-0!

First SPWLA Board meeting 2019-2020

As to my official duties with the SPWLA, this column was the first thing on my list. Reporting for the professional and student chapters will resume in the next column once I've had a chance to get to know them through correspondence. I will endeavor to promote the SPWLA up here in the north and down south as much as possible. I am excited to get working with the new board and to see what we can accomplish.

Back to the symposium, the 60th anniversary SPWLA Symposium in The Woodlands was great to attend and learn from. The venue and work put on by the planning committee was top notch. I hope to see everyone June 20–24, 2020 when the Canadian Well Logging Society in my home country and province hosts the 61st in Banff, Alberta, Canada.

Regional Understandings – Middle East and Africa

Shouxaing “Mark” Ma
2019–2020 MEA
Regional Director

Dear Colleagues,

With the conclusion of the 2019 Woodlands SPWLA Annual Symposium, a chapter of SPWLA has been turned over and a new one is ahead of us. To the newly elected board members, welcome on board!

At the beginning of this new fiscal year, I would like to remind all of our vision and missions, which may be highlighted as below;

- To engage and empower the petrophysicists community to meet petrophysical needs of global exploration, development, production, and abandonment.
- By collecting, disseminating, and exchanging petrophysical knowledge and technologies for the benefits of upstream community, and
- By providing opportunities for professionals to enhance their technical and professional competences.

To realize the above vision and achieve those missions, we need to actively participate in society activities and help each other to realize our professional goals. In the current era of internet of things, one effective and convenient way to collect, disseminate, and exchange knowledge and technologies are through professional networking.

About a year ago, I created a LinkedIn group titled Learning and Practicing Petrophysics Together (https://www.linkedin.com/groups/8686270) and currently it has close to 1,000 members. If you are a member, please be active and share your expertise for “Teaching is the Best Way of Learning.” If you are not a member yet and would like to be a part of the group, please join to network with other petrophysicists, you will not be disappointed.

Happy Learning!
S. Mark Ma

Katerina Yared
Vice President Education

Dear Petrophysics Aficionados,

I was happy to have seen and meet a lot of you at the 60th SPWLA Annual Symposium! What a great event and what a great turn out! Thank you to all the organizers!

Now looking ahead for my second year as VP of Education I hope to bring more avenues of knowledge sharing with our members and always welcome new ideas.

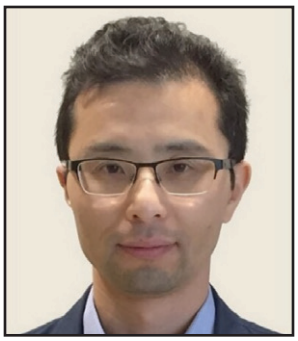
We will have our monthly webinars kicking off soon and I will encourage you all to bring forward names to add to our very successful Global Distinguished Speaker Lists. These are passionate folks willing to travel and share they knowledge and findings with their regional chapters as well as international ones. So keep the suggestions coming at VP-Eductaion@spwla.org.

I look forward to a great year filled with webinar series from our SIGs, our Distinguished Speakers, “the more you know” Series and the “Nuggets of Wisdom” Series and more as well as the International Student paperer competition coming up in Banff, Alberta, Canada, next year to top it all off.

Follow us on Facebook, LinkedIn and Twitter to stay “in-the-know”.

As always, it is an honor to serve the SPWLA members. Thank you for the opportunity!

Yours truly,
Katerina Yared
SPWLA VP Education 2018–2020



Lin Liang
2019–2021 VP
Information Technology

First please allow me to acknowledge my predecessor, Mehrnoosh Saneifar, who has done excellent work during her term. Her dedicated efforts enriched the SPWLA community in different aspects. Particularly, the introduction of the mobile app for the Annual Symposium has been proved to be very successful.

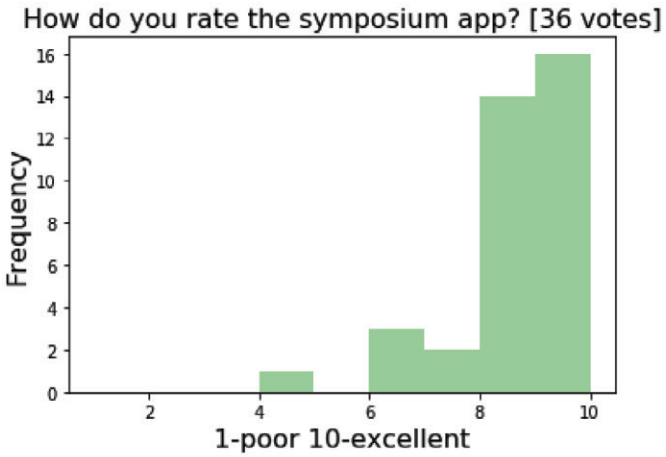
Again, thanks for the trust of the community, I officially started my volunteering duty serving as the VP of Information Technology for the SPWLA organization. As promised, I will contribute to further improve the quality of our organization to the next level. While meeting many of the attendees at the Annual Symposium, I have received quite a lot of feedback about different aspects. I will start to work on solving the issues, with their priorities based on communication with other board members and community members. Please shoot an email to vp-infotech@spwla.org if you have any suggestions on any IT-relevant matter.

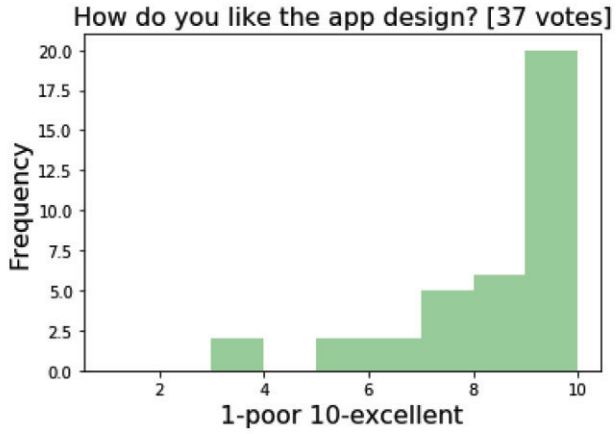
From the Symposium mobile app, we carried out a survey to collect opinions on the Symposium Technical Program as well as the mobile app itself. Overall, we received very positive feedback on the introduction of a mobile app, with some suggestions on further improvement. We will work with the vendor to see how we can improve it for the next Symposium. On the Technical Program part, we see some minor issues and the need for further improvement, as well. We did receive feedback about the quality of accepted abstracts. It seems the majority of people support the anonymous review and the parallel session model for the Symposium. With only 36 responses from over 800 attendees, the survey results presented below may not be statistically representative of the majority of app users.

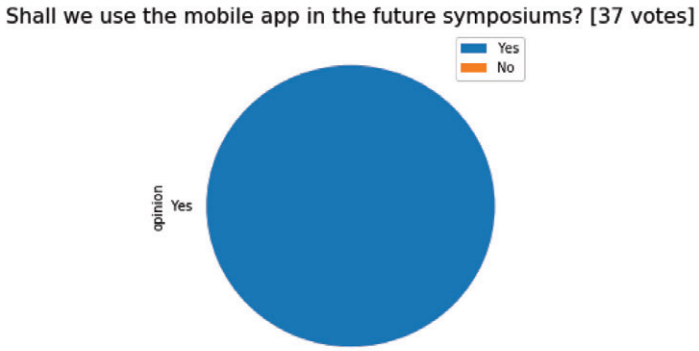
Lastly, I am looking forward to working with other board directors, volunteers, and members to continue the success of SPWLA community and maintain a great platform for knowledge sharing across the industry and academy.

Below is a summary of the feedback received from the survey carried on the Symposium mobile app.

The survey about the APP itself:







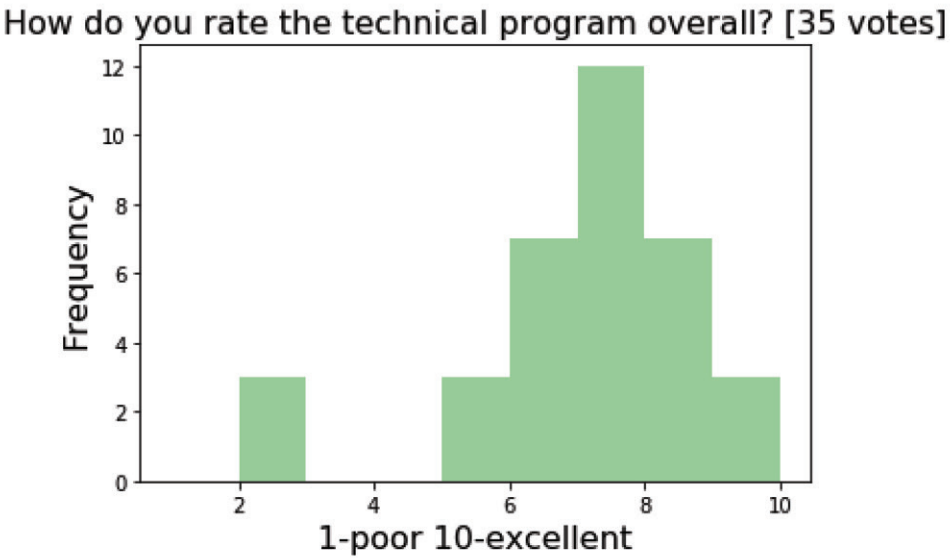
Q4: What problems did you come across in the app? [24 responses]

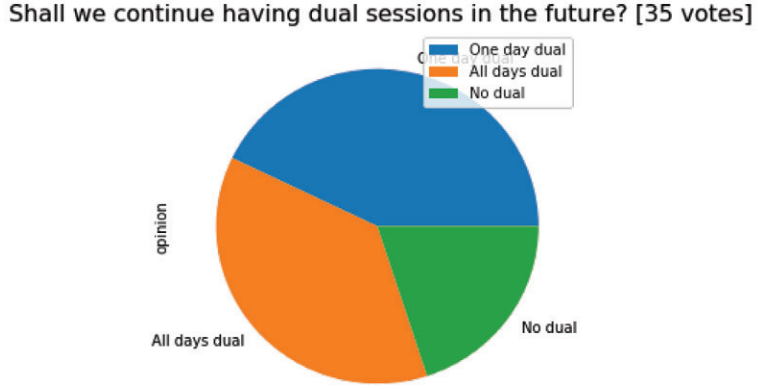
#1	Was not updating properly.
#2	"My schedule" tab needs to be improved to show venue of presentation.
#3	No problems.
#4	None.
#5	It should have live webinar.
#6	No problems as of yet. A map of the venue and locations of booths would be a plus.
#7	It's all good.
#8	None.
#9	I wish it was easier to add talks and posters to "my schedule" ... overall a nice app with good push updates.
#10	None.
#11	It crashes a lot.
#12	Crashed a few times on Monday, going back to home screen.
#13	Notification could be used more often for updates.
#14	Missing room location information. The app is slow to load when you first open it.
#15	None.
#16	"My Agenda" - would be nice to be able click on a selected day first; "Attendees" - Names-companies are incorrectly matched.
#17	No problem, but could be simplified (e.g., I used "Agenda" to navigate talks and found no use for the "Technical Program" link/view).
#18	Need to simplify. There are things all over and difficult to find. Needs significant improvement.
#19	Would crash when looking up details of attendees.
#20	None.
#21	No problems, everything went well.
#22	None.
#23	None.
#24	Every time you open the app the event logo came up instead of going directly to the information. At the beginning it was difficult to navigate but using it made it somewhat better.

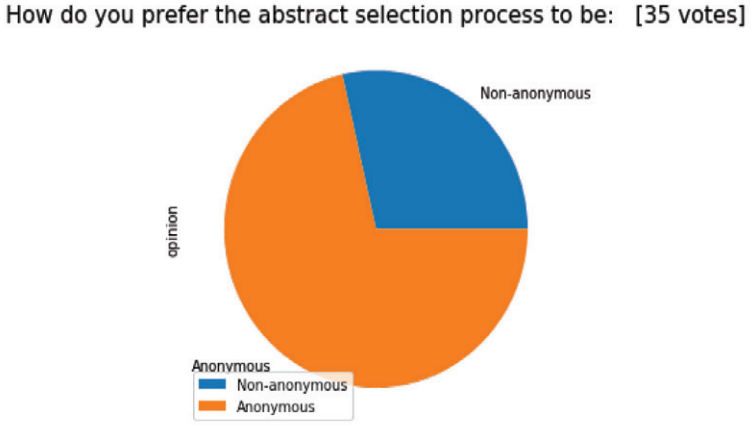
Q5: Any other thoughts on the mobile app? [11 responses]

#1	No.
#2	No, it's very nice app.
#3	I think it's an excellent idea to have an app like this. Any changes are easy to communicate.
#4	.
#5	Strive to organize app around a map of the facility if continue using dual sessions.
#6	Need contact info for attendees.
#7	Would be nice to have a map in the app. And have a safety section.
#8	Make it easier to add a talk to "My Calendar".
#9	I enjoyed the push updates.
#10	Thank you!
#11	It was very useful.w

The survey about the Technical Program:







Q2: What are your thoughts on the dual sessions (refer to comment section)? [33 responses]

#1	I think it's great!
#2	Good use of time and interests.
#3	I did not like having to choose between the sessions.
#4	Like them.
#5	It was a good option. Allows people to attend talks that are more relevant to their interests and job.
#6	Worked better than I expected. I suggest dual sessions for three days next year and eliminating posters.
#7	In general, positive. However, the presentations do not always start ontime. Timing need to be synchronized better between the sessions.
#8	I like the dual sessions.
#9	Like the dual sessions, but the coordination of talks in the downstairs conference room was horrendous. The first talk in the morning was not ready and, in the session right after lunch, the wrong talk was queued up, followed by a 20 min delay. Incredible, given that both instances occurred right after long breaks.
#10	OK.
#11	Need to maintain the quality of abstract selection.
#12	Liked.
#13	Good.
#14	Never! No need to increase the presentations. We should make better selections.
#15	I like it.
#16	Worked well, but be sure that the dual sessions do not overlap or are exclusive in fields of interest.
#17	I liked the ability to fit more content into the symposium via dual sessions.
#18	I'm still not a fan.
#19	No good.
#20	It worked very well. We should repeat it in the future.
#21	I don't mind it.
#22	I really liked having the option of multiple talks.
#23	Great. Do it for all three days.
#24	OK
#25	I think it is
#26	I liked it.
#27	I like having the dual session on only one day.
#28	There were presentations and both dual sessions that I wanted to see that were being presented at the same time. So, therefore, I do not like the dual sessions.
#29	I like it as we can have more papers selected. I'm sure some papers rejected were better than some of the accepted papers.
#30	I prefer single sessions. this differentiates SPWLA in a good way.
#31	The idea is Ok but needs good presentation resources for both venues and they need to be closer. There were technical problems due to lack of supervision. These things cannot run in autopilot.
#32	Worked well, I did not attend both, but the topics of the parallel sessions were well chosen to allow you to choose. I liked the idea of limited dual sessions, try not to do it every day
#33	The session chairs need to stick to the timing exactly and the session rooms need to be adjacent to enable people to go back and forth. I will also put a comment here about the program selection since there is no other place for comments. I am very disappointed with the selection of the papers for sessions 2 and 6 as they were dominated by the work of single teams (Chevron for Session 2 and University of Texas Austin for Session 6). I would expect the program committee to introduce more diversity. I am also disappointed about the fact that the work presented in Session 2 had nothing really ground breaking.

The Q5 on "Which category you prefer to see more technical papers in" is dropped due to very limited response, which is not statistically meaningful.

From the Editor

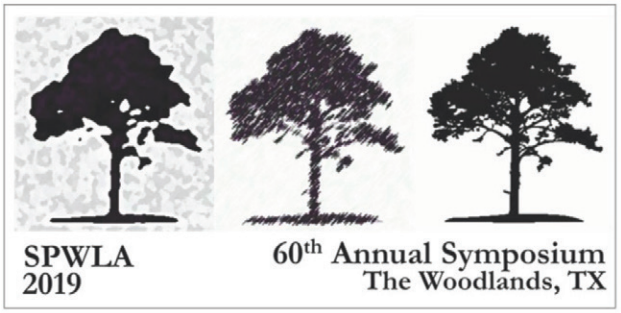
Tom Neville
VP Publications 2019–2020

Welcome to the July edition of *SPWLA Today*. June has been a very busy month for our Society, with the flagship event on our calendar, the SPWLA Annual Logging Symposium, being held at The Woodlands, Texas. I was fortunate enough to be able to attend the symposium, and would like to congratulate the Symposium Organizing Committee, led by Jeff Crawford, for delivering an excellent six days of technical and social activities. This edition of *SPWLA Today* features highlights of the symposium and associated events.

This is my first column as Vice President Publications, and I am honored to have the opportunity to lead SPWLA publications over the next year. In a member survey recently conducted by the Society, results of which are reported herein, *Petrophysics* was identified by the survey respondents as the most valued benefit of SPWLA membership and I will be working this year to ensure that this continues. I would also like to recognize my predecessor, Carlos Torres-Verdin. Carlos' outstanding work over the last two years has left *Petrophysics* in a very strong position.

SPWLA Today is also the result of Carlos' vision to separate peer-reviewed technical papers from other content that had previously coexisted in *Petrophysics*. The results of the member survey were not quite so positive for *SPWLA Today*, although ratings were in line with many of the other benefits that SPWLA provides. *SPWLA Today* is still a work in progress and it will take some time to find a natural role within the portfolio of communication tools that the Society uses. In defining this role, we need your help. We welcome your comments and suggestions about, and criticisms of, *SPWLA Today*, so that we can continue to develop it into a tool that serves your needs as members of our Society.

Tom Neville
Vice-President Publications
tom.neville@formation-evaluation.asia



The Houston Chapter of SPWLA served as the host chapter and organizing body for the SPWLA 60th Annual Logging Symposium. The event was held in The Woodlands, Texas, at The Woodlands Waterway Marriott, June 15 to 19, 2019. Based on feedback from delegates, sponsors and exhibitors, the event can be considered a success. The total number of attendees this year exceeded 800.

THE VENUE

The conference was hosted at The Woodlands Waterway Marriott. SPWLA celebrated a successful 50th annual symposium at this same site in 2009, making it a preferred location to host in 2019. The newly renovated space has a compact layout, allowing delegates to efficiently travel from the hotel to the technical sessions, exhibition, lunches, and social events. This layout was also ideal for the implementation of parallel technical sessions, with travel between auditoriums consisting of a short escalator ride. A variety of restaurants and shops are located within walking distance as well as hiking and bike trails, pools, public art, water sports, and golf.

FIELD TRIP

This year's field trip was a trip south to Galveston, Texas, to see typical vertical and lateral facies associations in fluvial, deltaic and barrier island sedimentary successions. Fluvial processes dominate on the upper delta plane, whereas the lower delta plain is subject to marine influence. Delta fronts comprise nested complexes of distributary channels, mouth bars, tidal bars, and reworked delta-front sediments. The trip was led by Julia Smith Wellner, University of Houston. I heard positive feedback from those that attended, although I wish I could have turned down the heat and humidity for them.

WORKSHOPS

Eight full-day workshops were delivered on Saturday and Sunday:

Workshop 1: "Practical Applications of Acoustics" Short Course
Instructors: Alexei Bolshakov (Chevron), Doug Patterson (BHGE), Jennifer Market (Lloyd's Register), Matt Blyth (Schlumberger), Philip Tracadas (Halliburton), Brian Hornby (Halliburton), and Rob Vines (Shell International E&P).

Workshop 2: "Advanced Applications of Wireline Formation Testing"
Instructors: Sefer Coskun (BHGE), Richard Jackson (Schlumberger), Tony Van Zuillekom (Halliburton), and Mark Proett (Mark Proett Consulting).

Workshop 3: "Saturation-Height Modeling"
Instructor: Iulian Hulea (Shell Global Solutions BV)

Workshop 4: "Petrophysical Applications of Imaging And Image Analysis"
Instructors: J. Funk (Core Imaging Consultants) and L.A. Hathon (University of Houston)

Workshop 5: "Advances in Resistivity and Dielectric Logging"
Instructors: Hanming Wang (Chevron), Roland Chemali (Occidental Petroleum), Hezhu Yin (ExxonMobil), John Rasmus (Schlumberger–Retired), Teruhiko Hagiwara (Saudi Aramco), Michael Rabinovich (BP), and Michel Claverie (Schlumberger)

Workshop 6: "Value of Data: Getting the Right Balance in Exploration and Appraisal Wells"
Instructors: Paul Lumens (Shell) and Clive Sirju (CNOOC International)

Workshop 7: "Cased-Hole Formation Evaluation"
Instructors: Ahmed Badruzzaman (Pacific Consultants and Engineers) and Dale Fitz (Consultant)

Workshop 8: "Applications of Geomechanics in Conventional and Unconventional Reservoir Development"
Instructors: A. Mitra (MetaRock Laboratories), M.T. Myers and L.A. Hathon (University of Houston)

STUDENT PAPER COMPETITION

The student paper competition was held on Sunday, June 16. The competition was chaired by Jiaxin Wang and organized with the VP Education, Katerina Yared. The program consisted of 12 oral presentations, nine of which were presented onsite. The other three were presented via GoToMeeting, with two presented from Cairo, Egypt, and one presented from Beijing, China. Six e-posters were presented in two separate sessions.

The competition was judged by: Grant Goodyear, Xiaogang Han, Jiefu Chen, Geoff Page, Weijun Guo, E. C. Thomas, Chandramani Shrivastava, Motta Stephano, Jiaxin Wang, and Katerina Yared. Their help, insightful comments, questions and decisions were invaluable. The quality of the oral and poster presentations was excellent, and all students are to be congratulated on their work. The judges agreed on the following awards:

- Best Undergraduate Student Oral Presentation: Vanessa Rios (Universidad Industrial de Santander)
- Best Masters Student Oral Presentation: Sabya Prakash (University of Houston)
- Best PhD Student Oral Presentation: Sercan Gul (University of Texas at Austin)
- Best Poster Presentation: Muhammad Bilal Malik (University of Punjab Pakistan)

At the conclusion of the event, prizes of $1,000 US for 1st place were awarded by Katerina Yared and Jiaxin Wang.

OPENING REMARKS AND KEYNOTE

Jeff Crawford, Chairman of the Symposium, called the meeting to order and welcomed attendees. Jeff also introduced his committee and thanked them, the SPWLA office, and the international board of directors for their time and efforts in the planning of the symposium. Finally, he introduced the keynote speaker, Arvind Sharma, VP Data and Analytics, TGS.

Arvind Sharma believes that data integration and machine learning will be pivotal to this industry's future success. He has 10+ years' experience in seismic research; data processing and analysis, exploration prospecting, and drilling. Arvind holds a BS and MS from IIT Kharagpur and a PhD from Virginia Tech. Arvind has worked more than 10 years in seismic research, including data processing and analysis, exploration prospecting, and drilled several wells. At TGS, Arvind pioneers the Data and Analytics group through the development of new AI and Machine learning products and services. His mission is to create a platform to integrate and analyze all available sub-surface information for risking and decision making. In his spare time, Arvind enjoys rooting for the Houston Rockets with his wife and daughter.

Arvind reviewed the state of the oil and gas industry and various disruptive technologies, citing implementations of artificial intelligence as the latest invocation of disruptive technology. He then presented a few examples of AI in action, then closed with a discussion of future challenges.

TECHNICAL PROGRAM

Following the keynote presentation and introductions, Jim Hemmingway (then, VP Technology, and currently, President-Elect), opened the Technical program. The full program lasted three days, with 15 sessions of oral presentations and 4 e-poster sessions for a total of 67 oral presentations and 46 e-posters.

The session topics included:

- Formation Evaluation of Conventional Reservoirs (4 Sessions)
- Formation Evaluation of Unconventional Reservoirs (2 Sessions)
- Completions, Reservoir, and Production Surveillance
- Formation Evaluation Behind Casing
- New Borehole Logging Technology (3 Sessions)
- Machine Learning (2 Sessions)
- Conventional and New Technology
- Case Studies

SOCIETY FUNCTIONS AND SOCIAL EVENTS

The Icebreaker Reception took place at the Westin Hotel at The Woodlands on Sunday night, hosted by Halliburton. Guests that decided to brave the heavy rains and high winds were rewarded with a beverage in their hand, tasty hors d'oeuvres, and great conversations with colleagues. It was a great event for reconnecting and setting the stage for the start of the technical sessions.

The Annual Business Meeting and Luncheon was held on Monday following the opening technical session. During this meeting, outgoing president Zhipeng "Zach" Liu passed the gavel to incoming President Jesus Salazar. The President and Board Members gave brief reports and the new 2019–2020 SPWLA Board of Directors was introduced and welcomed.

Baker Hughes, a GE Company, sponsored the Monday Evening Social event at the Haras Hacienda, a premier Lusitano breeding farm and horse show venue. Dubbed the "Social A-Fair", guests were greeted with live music, fair-style games, a horse show demonstration, and a variety of beverages and food truck options from which to choose. For those guests that were looking for an authentic Texas experience, this event fit the bill.

The SPWLA Annual Awards Presentation and Luncheon took place on Tuesday. During this time, the Society recognized multiple awardees for their significant contributions to SPWLA. Awards were presented for Distinguished Technical Achievement, Distinguished Service, Meritorious Service,

Outstanding Professional Chapter, and Outstanding Student Chapter. The "Best of 2018" were also recognized, with awards for top article published in *Petrophysics*, top symposium paper, and top e-poster. Then, the Distinguished Speakers, along with their regional counterparts, were also recognized. Those that were recognized are listed later in this article. Congratulations to all award recipients!

After a day that saw the initial use of parallel technical sessions, Schlumberger hosted the Tuesday "Light Up the Night" social event at the Cynthia Woods Mitchell Pavilion. Guests were treated to a Vegas-style experience, with casino games, a light show, unique and entertaining performers, and great food and beverages. This was definitely a venue that closed out the 2019 social events with verve.

On Wednesday the current and former cadre of SPWLA met for Leadership Luncheon. Chapter Presidents, Past SPWLA Board of Directors, Past Presidents, and SIG Coordinators were invited to this complimentary lunch. This meeting provided an excellent opportunity to exchange ideas between those that have led and are currently providing leadership within SPWLA.

SPOUSE/GUEST ACTIVITIES

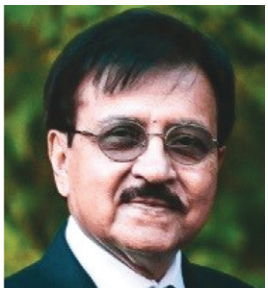
The spouses/guests enjoyed three great events during the symposium. On Monday, guests took a shopping tour of Market Street, a nearby area constructed to resemble an old town square with restaurants, entertainment, clothing stores, and many specialty shops. On Tuesday, guests ventured outside of The Woodlands to Brenham, Texas, to visit the Blue Bell Creamery and the George H.W. Bush Presidential Museum and Library, learning both the 'old fashioned' method for creating the region's favorite ice cream and the history behind the 41st president of the US. Wednesday began with brunch at Chocolate Passion, a Venezuelan chocolatier using fine and rare Criollo chocolate located in Conroe, followed by a road trip to the beautiful Tuscan-style award-winning Bernhardt winery located in Plantersville, for sumptuous wine tasting and a tour with the proprietor.

SPWLA AWARDS

Distinguished Technical Achievement

Songhua Chen currently is Senior Manager of NMR Sensor Physics Discipline at Halliburton. Since joining Halliburton eight years ago, he has been leading a team of scientists and mathematicians to research and design new wireline XMR and LWD MRIL sensors, as well as to optimize NMR data acquisition, processing, and interpretation methodologies. Most recently, his interest focuses on carbonate pore typing and unconventional reservoir fluid identification. Prior to joining Halliburton, he was with Baker Hughes for 15 years as a staff scientist and NMR Interpretation Project Leader, and later became Senior Manager of Integrated Interpretation group to develop technologies involving NMR, geochemistry, fluid sampling/testing interpretations, and pore scale modeling. Prior to working in the energy service industry, he was a Senior Scientist at Texas A&M University. Songhua holds a BS in Physics from Southeast University, Nanjing, China, and a PhD in Physics from University of Utah, Salt Lake City. Songhua is an inventor or coinventor of 56 U.S. patents in NMR downhole sensors, data processing and analytics, inversion, core analysis, and integrated petrophysics. He authored or coauthored 98 publications including 1 book chapter, 30 peer-reviewed journal papers, and 67 conference proceedings. He has been an active member of SPWLA, SPE, and past member of American Physical Society, SEG, and SCA. He has cochaired two SPWLA NMR topical conferences and served once on the SPWLA Technology committee. He was selected twice as a SPWLA Distinguished Speaker in 2006 and 2013, respectively.

Distinguished Technical Achievement



Ahmed Badruzzaman has sought to understand physics basics in complex nuclear systems, from novel fission reactors to inertial confinement fusion to downhole logging, during a nearly 40-year R&D journey through Chevron, Sandia National Laboratories, Schlumberger-Doll and Babcock & Wilcox, and teaching at University of California, Berkeley. An early practitioner/developer of simulation techniques, it has been Ahmed's modus operandi in research throughout. He is currently an SME consultant to the US Department of Energy on alternatives to radionuclide-based logging tools to mitigate source risks. His interest in alternatives began in early 1980s, at Schlumberger-Doll, where he studied response of an experimental LINAC density tool. He helped develop Chevron's in-house Source Handling Guideline, prepare IAEA's draft logging source safety guide, and revise Vienna-based WINS' Best Practice Guide on logging source security. He was an official reviewer of US National Academy of Sciences' 2008 report to Congress, "Radiation Source Use and Replacement." During 20+ years in Chevron, Ahmed studied advanced tools (LWD and C/OPNC) in difficult-to-calibrate wellbore

conditions, developed novel algorithms in complex formations, proposed advanced logging measurement concepts, and studied high-temperature gas reactors for unconventional resource recovery. His theory-based three-phase C/O-to-So equation, termed as 'Badruzzaman correction' by a service company colleague, has been used in California and Indonesia steamfloods, to accurately locate several hundred million barrels of previously unaccessed reserves. He developed the first multiple-detector PN tool concept leading to a 1998 patent on a through-casing inelastic n-gamma density (INGD), and a 2004 SPE paper on multiple parameters from such a tool. Now an independent researcher, he recently revisited basics of INGD concept and generators as alternatives to Am-Be sources for neutron porosity. Author of 45+ papers, two US patents, and an upcoming textbook on Nuclear Logging, Ahmed is a Fellow of American Nuclear Society, a two time SPE Distinguished Lecturer, a two-time SPWLA Distinguished Speaker, a former editor of *Petrophysics*, and founder-chair of SPWLA Nuclear SIG. Avid proponent of mentoring the next generation, Ahmed offered a graduate course, Subsurface Nuclear Technology, at UC Berkeley during 2001–2007. He now coteaches Berkeley's Big Ideas Course, Energy and Civilization. Ahmed holds PhD in Nuclear Engineering and Science from Rensselaer Polytechnic Institute, Troy, New York.

Distinguished Technical Achievement

Geoffrey Page studied physics at the Royal College of Science in London. He began his oilfield career as a Dresser Atlas wireline engineer in France in 1980, during which time he logged some wells in Pechelbronn in North East France – the home of logging! In 1988 after a spell working offshore in the North Sea he was transferred to Aberdeen "for 1 to 2 years" as the North Sea Geoscience manager, moved into Petrophysics, and is now Region Petrophysics Advisor and global subject matter expert (SME) for BHGE, still based in Aberdeen after over 30 years! He is a former President of the Aberdeen chapter of the SPWLA (AFES) and was honored with a "life membership". He has written and presented many papers, and been a silent contributor on many more, helped organize many of the global conferences, for both SPWLA and other professional societies, including SPWLA 2008 in Edinburgh and London 2018. In 1988 two other projects also started which have come together: Aberdeen University asked if they could come and visit the operational wireline base to view the logging equipment as part of the new, now very successful, Integrated Petroleum Geoscience (IPG) MSc course. Around the same time some of the support services managers in his company asked if they could be taught a bit more about exactly what the company did – a course that became known as "Logging for Accountants." Putting these together merged into an introductory petrophysics course that has been given to around 500 IPG students, and is part of the MSc qualification. This and other logging technology courses, have also been presented to another 500+ industry professionals. For many of them this was this first time they had encountered "petrophysics" and were inspired to now be seasoned petrophysicists in their own right. Geoff now spends a large part of his time teaching and mentoring both within his own company, BHGE, and externally, to help introduce old and new technology services to colleagues and customers, as well as helping to push the frontiers of petrophysics forward in new areas such as geothermal.

Distinguished Service

Tegwyn J. Perkins has been with Lloyd's Register (LR) for eight years and currently serves as a Principal Technical Advisor where he has overall responsibility for all technical activities in the Americas. Tegwyn has almost 30 years in the industry: before LR he spent 14 years with Halliburton where he served in various formation evaluation and managerial software positions and previously he worked for both Z&S Consultants and Intera/Exploration Consultants Ltd. Tegwyn earned his doctorate degree in Applied Mathematics and Numerical Methods from University of Wales, Aberystwyth, and his post-doctoral study on the "Carrying Capacity of Drilling Fluids," from University of Plymouth, England, was sponsored by BP. His undergraduate studies were also carried out at University of Wales, Aberystwyth. He has coauthored 13 papers on various aspects of petrophysics and formation evaluation and his current technical interests include borehole imaging, geosteering and machine learning. He is proud to have served as the 2009–2011 and 2013–2015 SPWLA VP Information Technology as well as on various Symposium, Education and IT committees over the years. Currently, he is the webmaster for SPWLA2019.com and the Aberdeen Formation Evaluation Society and maintains the Curve and Tool Mnemonics database for SPWLA.org (20,000 entries and counting!).

Tegwyn has twice replaced the abstract submission and review program! The current system was successfully used for the 2019 Symposium and is also available for other SPWLA

meetings and conferences. On a personal note, Tegwyn is an avid sports enthusiast who manages (and plays for) his own amateur football team. He also enjoys rugby, orienteering, badminton and golf.

Meritorious Service

Chicheng Xu obtained his bachelor's degree in Physics from the University of Science and Technology of China in 2002, and master's degree in Physics from the Chinese University of Hong Kong in 2004. After working for more than four years for the Schlumberger Beijing Geoscience Center as a petrophysics software engineer, he continued his education with the Formation Evaluation & Petrophysics consortium at the Petroleum & Geosystems Engineering Department of UT Austin in 2009. He was awarded a PhD in Petroleum Engineering in 2013. During his PhD research, he developed a series of novel petrophysical rock-typing methods and workflows with multiscale subsurface data and published more than 20 technical papers. From 2013 to 2017, he worked as a petrophysicist/ rock physicist for BP America and BHP Billiton to support US asset operations and reservoir characterization in deepwater turbidite fields as well as onshore unconventional fields. Chicheng is currently working as a research petrophysicist and project leader in Aramco Houston Research Center. His research focus is on petrophysical reservoir characterization using advanced computational techniques and data analytics for interpretation, classification, and modeling based on multiscale subsurface data integration. Chicheng Xu has been actively contributing to professional societies such as SPWLA, SPE, and SEG since his PhD years. He served on the SPE Reservoir Description and Dynamics committee (2016–2018) and the Formation Evaluation subcommittee of SPE ATCE (2015–2019). He is an associate editor of *Interpretation* the journal copublished by SEG and AAPG, *Petrophysics*, and SPE *Reservoir Engineering and Evaluation*. During his editorial tenure, Chicheng has led publication of several special issues on the cutting edge petrophysics research topics such as Facies Classification/Rock Typing and Petrophysics Data-Driven Analytics (PDDA). He is chairing the SPWLA PDDA SIG and was selected to receive the regional Formation Evaluation technical award by SPE–Gulf Coast in 2018.

Meritorious Service

Irina Borovskaya is the founder of Iblytics LLC, a boutique consulting firm focusing on strategic data-driven decisions. Irina Borovskaya has more than 15 years of upstream oil and gas experience in conventional and unconventional assets, in onshore and offshore environments during exploration, appraisal and development phases. Prior to founding Iblytics LLC she worked in ConocoPhillips in Lower48 Unconventional plays assets, leading teams and projects; and prior to that—in Schlumberger, where she held various positions in research, consulting and operations while working in the US, Russia and Brazil with Data and Consulting Services, R&D and Drilling and Measurements Segment. Ms. Borovskaya received her PhD in Mathematical Modeling, BSc and MSc in Applied Mathematics and Physics from the Moscow Institute of Physics and Technology, Russia. She is now pursuing an MBA at the University of Chicago Booth School of Business. Irina Borovskaya served at the SPWLA Brazil Chapter Board (2012–2013). Ms. Borovskaya has been on the Board of Directors of the Houston Chapter of SPWLA as Editor, Treasurer and President (2014–-2018). She also served on boards for the SPE NYNE Petroleum and the SPE Brasil Sections (2010–2013). Irina Borovskaya has 18 publications on petrophysics, stochastic modeling and aeroacoustics.

2018–2019 Outstanding SPWLA Professional Chapter

London Petrophysical Society, the London Chapter of SPWLA

The LPS is a registered charity that exists to promote, for the public benefit, education and knowledge in the scientific and technical aspects of formation evaluation. We do this through a regular series of evening technical meetings and topical one-day seminars, and through our Newsletter.

We provide educational support through the Ian Hillier University bursary and grants scheme, and other educational support, such as matching universities with industry donors of data for research, and student travel expenses to our events. We are a thriving chapter with over 300 members. Our first meeting was held on 15 March 1973 under the presidency of Pip Threadgold after the SPWLA granted formation of the local

chapter earlier that year on 25 January 1973. André Poupon of Schlumberger was the speaker with the title "Logging—Past Present and Future". The LPS holds its evening meetings and its seminars in the historic and beautiful Geological Society buildings, in Piccadilly, London. The LPS hosted the SPWLA Annual Symposia in 1987 and 2018, and hosted European symposiiums in 1983 and 2002. We also hosted the seminar that led to the definitive *Russian Style Formation Evaluation* book edited by Bob Harrison. LPS is very proud be awarded the Outstanding Chapter Award 2019. Thanks to all the committee involved in the LPS in recent years and in the London Symposium committee for all their hard work.

2018–2019 Outstanding SPWLA Student Chapter

The University of Texas at Austin

The Student Chapter of SPWLA at The University of Texas at Austin has consistently and frequently organized a significant number of events to highlight and disseminate petrophysics and formation evaluation activities among students, academics, and local professionals. Our events have emphasized the importance of formation evaluation practices in the description and production of hydrocarbon reservoirs around the world. Furthermore, we have successfully reached out to the geosciences and engineering communities to inform them about our profession and our technical challenges. We are planting the seeds of future formation evaluation specialists who will eventually enrich and command the SPWLA. As a result, a large number of UT Austin students is seriously considering the profession of formation evaluation as their technical career. Below is a summary of the major chapter events and achievements that took place between March 2018 and March 2019:

Events

- The chapter hosted nine technical events, including presentations by two current SPWLA Distinguished Speakers, two SPWLA Regional Speakers and the SPWLA President-Elect, Jesus Salazar.
- The Chapter participated in three additional outreach events at The University of Texas at Austin. At these events, Chapter members led approximately 800 hands-on demonstrations that taught elementary, middle, and high school students basic concepts related to petrophysics, petroleum engineering, and geological sciences.

Annual Symposium Involvement

- Two of the Chapter's nominees for the Student Paper Contest placed 1st in their respective divisions. Michael Wang earned 1st place in the Bachelor's division and Runqi Han earned 1st place in the PhD division. This was the second consecutive year UT won first places in both divisions.
- Artur Posenato Garcia, President of the Student Chapter of SPWLA at UT-Austin, was named a 2018-2019 SPWLA Distinguished Speaker for the second year in a row. Additionally, Chapter member Chelsea Newgord received the designation of 2018–2019 SPWLA Distinguished Speaker.

Social Media

- The SPWLA at UT-Austin Facebook page currently has over 1,100 followers and the recent creation of the Chapter's LinkedIn profile helped to strengthen our social media presence.

The Student Chapter of SPWLA at The University of Texas at Austin is very proud to receive the Outstanding Student Chapter Award at the Annual Symposium for the second consecutive year.

***Petrophysics* Best Paper 2018**

"Improving Dielectric Interpretation by Calibrating Matrix Permittivity and Solving Dielectric Mixing Laws With a New Graphical Method"
Haijing Wang, Hanming Wang, Emmanuel Toumelin, Ronald L. Brown, and Luisa Crousse, Chevron

Symposium Best Paper Presentation 2018

"A Revolutionary X-Ray Tool for True Sourceless Density Logging With Superior Performance"
Matthieu Simon, Avto Tkabladze, Sicco Beekman, Timothy Atobatele, Marc-André De Looz, Rahul Grover, Farid Hamichi, Jacques Jundt, Kevin McFarland, Justin Mlcak, Jani Reijonen, Arnaud Revol, Ryan Stewart, Jonathan Yeboah, and Yi Zhang, Schlumberger

Symposium Best E-Poster Presentation 2018

"Borehole Acoustic Imaging Using 3D STC and Ray Tracing to Determine Far-Field Reflector Dip and Azimuth"
Nicholas Bennett, Adam Donald, Sherif Ghadiry, Mohamed Nassar, Rajeev Kumar, and Reetam Biswas, Schlumberger

Distinguished Speakers 2018–2019

Matthieu Simon
Avto Tkabladze
Nicholas Bennett
Artur Posenato Garcia
Chelsea Newgord
Stefan A. Hertel
Alberto Mendoza
Hani Elshahawi

Michael Thiel
Aidan Blount
Zheng Gan
Ravinath Kausik
Archana Jagadisan

Regional Speakers 2018–2019

Eduardo Breda
Paul Craddock
Iulian Hulea
Martin Kennedy
Maurizio Mele
Claudio Naides
Dzevat Omeragic
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Luis Quintero
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Andrew Hind (CGG)
Chris Jones (Halliburton)
Naveen Krishnaraj (University of Houston)
Clara Palencia (University of Houston)
Chicheng Xu (Aramco Services)
Yinxi Zhang (Equinor)

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Vice President Of Technology

James "Jim" Hemingway, Consultant, Manitou Springs, CO USA

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Christoph Arns (The University of New South Wales)
Sap Basu (ConocoPhillips)
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Philip Singer (Rice University)
Clive Sirju (CNOOC Ltd.)
Wanida Sritongthae (PTTEP)
E.C. Thomas (Consultant)
Chris Woods (Woodside Energy)
John Zhou (Maxwell Dynamics)

ACKNOWLEDGEMENTS AND CLOSING REMARKS

A huge thank you to all who were a part in making the SPWLA 60th Annual Logging Symposium such a success. Thank you to the SPWLA office: Sharon and Stephanie keep this ship sailing. Thank you to the SPWLA Board of Directors and Technology Committee for all of the time and effort you put in. Thank you to the organizing committee and the Houston Chapter for hosting such a successful symposium. Thank you to the Texas Tech Student Chapter for their work in photographing event proceedings and speaker gift presentations. Thank you to all the Sponsors and Exhibitors. Thank you to the management of The Woodlands Waterway Marriott and their Event Operations (Facilities, A/V, catering, etc.). Finally, a great thanks to all participants for making the 60th Symposium a huge success. I am looking forward to another great symposium next year. See you in Banff!

Jeff Crawford
General Chairman, SPWLA 2019

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

I joined SPWLA in 1981 because I was planning to attend the Annual Symposium in Mexico City that year. A paper that Stan Gianzero and I had written, "A New Look at Skin Effect," had been accepted for presentation. The paper examined how the formation conductivity level affected Doll's induction geometrical factor theory, which had been originally developed for a low-conductivity limit. Stan was presenting the paper and I was going along as coauthor and to learn more about SPWLA. I had attended an SPE Annual Meeting a couple years earlier and thought that the number of papers on drilling outnumbered the papers on formation evaluation to such a large extent that I didn't learn anything I could use in my work. I was hoping that SPWLA would be a better match.

The paper was very well received. There were many questions and comments both after the paper and between sessions. People came up to us with positive comments like "The 2D plots made it easy to visualize vertical and radial response together for the first time," and "Now I can see why the induction depth of investigation becomes shallower with conductive invasion." (See Fig. 1 for an example of the slides that the audience connected with.) I had become accustomed to people in research talking mostly about equations after a presentation and was surprised that this audience reacted so positively to graphics.

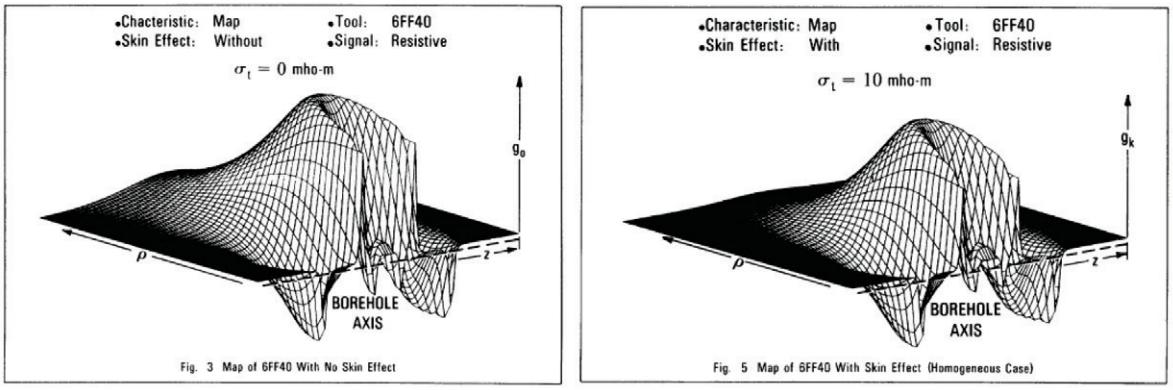

Fig. 1—2D response function plots. (a) Doll zero conductivity limit. (b) Homogeneous conductive 0.1 Ω-m formation.

I was particularly impressed by the expertise of the people I met at the meeting. They were both generalists and specialists at the same time. The big general problem to be solved was "Where are the hydrocarbons and how much is there?" To get an accurate answer, many specialists are needed, such as, experts in tool physics (electric, acoustic, nuclear), large-scale geophysics, smaller scale petrophysics, drilling engineering and fluid dynamics. This complexity makes problem solving both challenging and interesting. At the SPWLA Symposium, it felt like it was possible for everyone to personally contribute to the final general solution. The main challenge in fitting all the pieces of the puzzle together seemed to be finding a way to introduce your work to others at a level that could be understood by everyone. Then when others understood what you were doing, you could collaborate more closely in areas of mutual interest.

I returned to work with these ideas in the back of my mind, and with the intention of submitting a paper on a 2D finite-element induction modeling code I was writing with Steve Chang to the 1982 SPWLA Symposium. Then in July, I received a surprise letter from CWLS inviting Stan and me to present the SPWLA paper at their fall Meeting in Calgary because it had been voted Best Paper in Mexico City. That was the good news. The bad news was that Stan had accepted a job with Gearhart over the summer and I would have to be the one to give the talk. The pressure was on since Stan was a hard act to follow.

Fortunately, there was a Technical Communications Department at the lab that supervised the publication of *The Oilfield Review* and helped people prepare for conference presentations. I rehearsed my CWLS talk with Ernie Finklea, who was a long-time SPWLA member and had served on the SPWLA Technology Committee. He gave me good advice, like if a slide is too complicated to be read from the back of the auditorium, you lose half the audience before you start. He also advised that I keep simplifying slides and what I was going to say to the point where I thought the talk was too elementary. Then do it one more time, keeping in mind that the audience hasn't been working in this area 15 years like I had. I ended up doing a reasonably good job in Calgary. (Current SPWLA members may not remember the days before PowerPoint when "slides" were actually 35-mm

film. The graphics were done on the computer, printed and then photographed. The slides were developed, mounted in plastic frames and carried to meetings in a slide carousel. There was absolutely no way to make last-minute changes.)

I submitted Symposium papers on induction finite-element modeling in 1982 and 1983. The first was on dual-induction modeling and the second was on modeling tools operating in the megahertz frequency range (the now-obsolete Deep Propagation Tool and the 2-Mhz LWD tool then being developed). The slides showed and analyzed simulated logs in complex invaded thin-bed sequences that were difficult to interpret visually. The mathematical modeling equations were only discussed in the Transactions papers.

Modeling tool response in complex reservoirs clearly showed how inadequate the three Dual Induction-Laterolog measurements were for providing unique interpretation answers in these situations. Service companies began to think about opening projects to replace the workhorse tools that had been in use since 1962.

In 1994 and 1995, Weng Chew and I coauthored Symposium papers on fast semianalytic codes (analytic in depth, FEM radially) first for induction tools and then for laterologs. These codes could generate a simulated log on a VAX minicomputer in under 10 minutes. This made it practical to do fast log simulations both for tool design in engineering centers and for formation evaluation in field offices.

In 1986, 1987 and 1988 Tom Barber and I coauthored three "strange log" papers which catalogued environmental effects in cases where interpretation from the three resistivity measurements was ambiguous. Modeling was used to determine whether strange effects on logs were caused by actual geological features or by poor vertical resolution. In 1989 Tom and I presented a Symposium paper on a resistivity tool modeling package called ELMOD, which allowed log analysts in field offices to do their own strange-log modeling.

During the mid-1980s, improvements in digital electronics and modern signal processing techniques made it possible to use the imaginary part of the induction signal to extract information that was used to improve vertical resolution. Modeling showed that these improvements were effective, but not good enough. Work on design improvements continued, and service companies began introducing array induction and laterolog tools in the early 1990s.

In 1990 I coauthored a Symposium paper with Martin Luling and Richard Rosthal on interpreting logs in deviated wells for geosteering applications. Later that year, I presented a paper on the role of computer modeling in log interpretation at the European SPWLA Symposium. With the introduction of array tools, the need for log analysts to run modeling codes was eliminated for all but extreme 3D cases because forward-modeling codes were incorporated in inversion software.

I coauthored and presented papers at all of the SPWLA Symposiums in the 1980s, and ended up attending every SPWLA Symposium until I retired in 2007. Pictures of the Symposium cities of the 1980s are shown below. The pictures are actual photos I took or postcards bought in the cities. To make it interesting, see if you can identify the cities. They are all "oil cities" of the 1980s. The answers can be found at the end of the column.

To end my first decade of SPWLA membership, an interesting "incident" happened on my return flight from the European Symposium. The Pan Am flight was on an Airbus A310 that left Budapest Friday morning and was supposed to arrive in the afternoon at JFK airport in New York. There was a brief stop in Vienna to take on more passengers, and the flight was routine until the plane started its Atlantic crossing. Suddenly there was a jolt like extreme turbulence. Then the passengers sitting near the right wing began to complain that it sounded like the engine wasn't working. (Those of you who already know what an emergency landing is like can stop reading here.)

After about two minutes the captain announced that the starboard engine had lost oil pressure (the word "died" would have been more exact, but probably inappropriate at that time). He said that air traffic control had arranged for the flight to land at the nearest airport, which was in northern Scotland. He assured us that the Airbus was designed to be able to land with just one operating engine. However, the subsequent rapidness of his descent made it apparent that he wasn't too sure how long the operating engine was going to last.

I spent the longest 15 minutes of my life looking out the window at the closeness of the whitecaps on the waves. We must have leveled off at around a couple hundred feet. This was reassuring in a way because in meant that the drop would be short if the other engine cut out and it would be possible to launch life rafts.

We were immediately cleared for landing when we were in sight of the airport. The captain announced we were landing in Stornoway. The passengers talked among themselves and nobody had heard of the place. It turned out to be a British Coast Guard Station in the Hebrides Islands.

The landing was relatively smooth but nail-biting because of the short length of the military runway and having reverse thrust from only one engine. Finally, we taxied toward the terminal and stopped a short distance away. Power was shut off, and after several minutes, the captain announced we were safe because there was now no longer danger of fire.

Figs. 2 to 13. Captions below.

The next problem was how to get everybody off the plane. Because this wasn't a commercial airport, there were no stairways that were high enough to reach the Airbus doors. Pan Am decided not to deploy the slides because of risk of injury to the passengers. Instead, the resourceful British Coast Guard rigged up a basket on top of a fork lift that was used to lower 3 or 4 passengers at a time to the runway, as shown in Fig 14.

While waiting for buses to take us to hotels in town, we noticed that one of the tires on the plane was flat. We were told that this was a "controlled deflation" caused by sensors within the tire gradually releasing the air inside in order to keep the tire from exploding due to overheating. It was probably a good thing that we didn't know while we were on the plane that the tires were close to exploding.

Pan Am checked us into three hotels in town (the town was small) and paid for anything we wanted to eat for supper. The only inconvenience was that we had to sleep in the clothes we were wearing because we were instructed to leave all of our personal belongings on the plane in our tagged carry-ons. Nobody minded because at least we weren't sleeping at the bottom of the North Atlantic.

DAILY RECORD, Saturday, October 27, 1990 7

ATLANTIC JET IN STORNOWAY SOS

183 SAFE AFTER ALERT DRAMA

A JET with 183 people on board made an emergency landing in the Hebrides yesterday ...

After the pilot reported a loss of oil pressure in an engine of the Pan Am A310 Airbus flying from Vienna to New York, Scottish air traffic control at Prestwick advised Captain Curtis Briggs to land at Stornoway.

The plane – which also had a flat tyre – landed safely as fire tenders and ambulances stood by.

The Stornoway Coastguard helicopter was also scrambled in case the plane had to ditch.

Captain Briggs said that the emergency was caused by a loss of oil in the starboard engine.

By IAIN FERGUSON

The aircraft was 50 miles south of Stornoway at the time.

When they landed, it was found that there were no suitable gangways at the airport to remove the passengers.

BASKET

And they were

The hydraulic lift removes passengers from the plane after the emergeny landing at Stornoway

Fig. 14—Newspaper clipping from the Scottish *Daily Record* reporting on the emergency landing of my flight at the Stornoway Coast Guard Station in the Hebrides Islands in the North Atlantic.

In the morning we were bused back to the terminal where we boarded two small Pan Am planes that flew us to Heathrow (the Stornoway runway was too short for a fully loaded trans-Atlantic plane to take off). Those of us who still wanted to attempt a trans-Atlantic crossing were booked on a regular flight to Kennedy Airport on a 747, which arrived in New York safely on Saturday afternoon.

On Monday at the lab, the personnel director told me that I should fly again as soon as possible to avoid developing a fear of flying. So I wrote an abstract submitting a paper to the 1991 SPWLA Symposium.

Barbara Anderson

Figure Captions

Fig. 2—1981 Symposium, Mexico City conference hotel.
Fig. 3—1981 Canadian WLS Symposium, Lake Louise field trip.
Fig. 4—1982 Symposium, Corpus Christi city view.
Fig. 5—1983 Symposium, Calgary city view.
Fig. 6—1984 Symposium, New Orleans Jackson Square.
Fig. 7—1985 Symposium, Dallas International Airport.
Fig. 8—1986 Symposium, Houston Natural Science Museum.
Fig. 9—1987 Symposium, London Tower Bridge.
Fig. 10—1988 Symposium, San Antonio Alamo.
Fig. 11—1989 Symposium, Denver city view.
Fig. 12—1990 Symposium, Lafayette conference hotel.
Fig. 13—1990 European 13th SPWLA Symposium, Budapest city view.

On the Role of the Petrophysicist

Peter Day
Marathon Oil
Company—Retired

I was delighted to see the article in *SPWLA Today* [May 2019] on "Empowering Formation Evaluation, One Project at a Time!" It captures many of the frustrations I felt when last year I read "Petrophysics Training: Science or Software?" [*SPWLA Today*, July 2018]. Despite having completely dropped out of practicing anything technical associated with the oil patch, I still get annoyed when I read something that demonstrates that the author doesn't recognize that "log analysis" is not synonymous with "petrophysics". I don't wish to imply that one is intrinsically inferior to the other—"some of my best friends are log analysts"—but the skill sets implied by the two terms are vastly different.

The confusion between the terms is as pervasive as it is annoying. Log analysis is simply a skill that some, but certainly not all, "petrophysicists" might have. Unless one is being deliberately demeaning, none of the other subsurface professions are referred to by a specific skill that not all members of the profession might have: "geophysicists" are not routinely called "seismic processors"; or "reservoir engineers" referred to as "type-curve matchers"; or "geologists" as "petrologists"; so why should it be acceptable to equate "petrophysicists" with "log analysts"?

The problem really is not just pervasive, it's also fairly deeply embedded in some organizations: The geologist who has been on a formation-evaluation course who thinks that plugging numbers into a spreadsheet log-analysis calculator counts as "doing petrophysics"; the geophysicist who wants the "petrophysicist" to provide an edited sonic log so they can generate a synthetic; the production engineer who wants the "petrophysicist" to provide edited sonic and density logs so they can calculate a stress profile; the reservoir engineer who wants the "petrophysicist" to give them porosity and saturation for their simulation, and then wants to know what cutoff values should be used; the exploration manager who wants a pay-count from the "petrophysicist"; or the "petrophysicist" who simply cranks out the numbers without taking time to consider what might be done with them.

The unspoken assumption in each of the above examples is: "it's your job to provide me with data, you're not smart enough to actually do the real work." This, despite the fact that many petrophysicists are not only quite adept at such tasks as synthetics-modeling, stress-analysis and reservoir-simulation, but may actually be capable of doing a better job of the task because not only do they understand the science of the task, they also understand the origin and limitations of the data that are being used. Without wishing to appear to denigrate another technologist: Does the reservoir engineer really care about the origin of the porosity and saturation? Not usually, they just want the "best estimates" of those properties along the wellbore regardless of whether, for example, the saturation is derived from a resistivity log in some intervals, and from some type of capillary-function relationship elsewhere. Get those confused when you're trying to develop multiwell J-functions for a field using wellbore data and you run the risk of simply reverse-engineering the J-function that the petrophysicist used to generate some of the saturation numbers in the first place.

In order to pull petrophysics out of the log-analysis trap into which it has fallen, the "empowering" article offered advice to "speak the language of reservoir engineers, geologists, drillers, and geophysicists": If you can't communicate, then it really doesn't matter how good you are at your job! Yes, by all means learn to understand what the other subsurface technologists are all about—and, yes, the economics gurus as well—but while you are learning you should listen to how the other specialists are communicating across technical domains. In many environments the interdisciplinary communication might be essentially nonexistent, and when there is communication it is often limited to the needs of a specific, much-simplified technical transaction: "I want logs of porosity and saturation." The astute petrophysicist will quickly realize that, because of the range of their potential skills, they are well positioned to understand the needs of the other subsurface specialties.

As no doubt some petrophysicists have learned over the years, when it comes to the crunch, it's the petrophysicist who can actually communicate with the others on a project. I suspect that there are still some of us who remember seeing the "spider's web diagram" showing the petrophysicist at the center of the web and surrounded by all the other subsurface technologists. In that light, it really can be the petrophysicist who helps a team "gel": except that, unfortunately, "petrophysicists" are rarely assigned to teams, but instead are treated much like a common resource to be called on when needed for a limited task.

Thinking about the way forward, let me take 3D reservoir model building as an area where a petrophysicist might be a valuable fit. Model building is a task frequently consigned to someone who can drive the software rather than someone who has a broad understanding of the geotechnical disciplines that are involved: this should surely be an area in which a petrophysicist should excel—if only they would step up to take on the task, and demonstrate to the others that they do indeed have both a broad understanding of what everyone else is about, and also a good grasp on when the relevant professionals should be brought into the modeling process.

The well-rounded petrophysicist should actually be something of a "mystery" to those who have seen them in action: they should keep getting the question "what exactly is your technical specialty?" To which the answer should perhaps simply be "subsurface integration."

Statistically Evaluated Petrophysical Summaries: Some Issues with Spatial Correlation and Cutoffs in the Treatment of Random Measurement and Parameter Errors

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International B.V.

Methods for characterizing the uncertainty of a petrophysical result on a depth-by-depth basis have been published and are commonly practiced. There are several challenges in upscaling these uncertainties, especially when a petrophysical cutoff is invoked. The literature does not adequately address the subject of upscaling uncertain petrophysical results, even for random parameter or measurement errors. The intent of this paper is to address this gap to an extent. A custom-made Monte Carlo algorithm is described and applied to data from a clastic reservoir. Two distinct types of correlations are included in the model: (1) Correlation between random errors associated with each variable in the analysis, and (2) spatial correlation of random errors along the well trajectory.

Additionally, when a cutoff condition is used, a net-to-gross (N/G) ratio is evaluated in conjunction with a petrophysical property distribution of interest. It is technically correct to treat the N/G ratio and petrophysical property as a pair of jointly distributed random variables. In the examples presented in this paper, failing to do this lead to significant errors including a substantial underestimate of median (P50) reserves, a large underestimate of proven (P10) reserves, and an overestimate of possible (P90) reserves. In the absence of a cutoff condition, the effect of correlations between variables is greater on the measures of spread than on the median. This too is important, especially for estimation of proven and possible reserves.

INTRODUCTION

A petrophysical summary and a characterization of its uncertainty are often the most impactful result delivered by a petrophysicist. Summaries influence major investment decisions, such as property acquisitions and divestment, infrastructure for extracting and transporting reserves, locating and planning new wells, defining data acquisition programs, completion decisions, reserves calculations, and stimulation programs. Sources of uncertainty outside of the petrophysical analysis also affect these decisions. Because the petrophysical results are an input to many calculations related to other elements of uncertainty, a mischaracterization of a petrophysical distribution can have a compounding effect. As illustrated in the examples, this is important in even in the relatively simple case of the clastic reservoir studied here where the analysis was limited to consideration of random parameter and measurement errors on the petrophysical summary.

This paper is written from the point of view that a credible characterization of petrophysical uncertainties based, to the extent possible, on multidisciplinary input is an integral part of a petrophysical analysis. The authors reject arguments that a petrophysical uncertainty analysis is nonessential because a reservoir engineer, geologist, or geophysicist will make changes. This occurs as members of other disciplines have to incorporate alterations as the petrophysical work was done lacking access to all relevant information for a complete evaluation. The focus of the examples in this paper is on a few of the technical problems related to upscaling a petrophysical result. Nothing more will be said about organizational nor individual mindsets.

Methods for characterizing the uncertainty of a petrophysical result on a depth-by-depth basis have been published and are commonly practiced (Theys, 1999; Bowers and Fitz, 2000; Fylling, 2002; Verga et al., 2002; Stalheim, 2016). However, upscaling these uncertainties (i.e., averaging or smoothing over larger depth intervals) is not straightforward and often less understood, especially when petrophysical cutoffs are involved and random measurement and parameter errors are relevant. As such, this topic has not been treated adequately in the literature (to the knowledge of the authors). This paper addresses two issues with upscaling petrophysical results (1) the relationships between random measurement and parameter errors across depths, herein referred to as spatial correlation; and, (2) the evaluation of an N/G ratio and corresponding *joint* petrophysical property distribution when a petrophysical cutoff is used.

Standing practices for handling errors of the type addressed here involve “default assumptions” about spatial correlation and seem to be widely practiced, often without consideration by the petrophysicist. These assumptions do not seem to be explicitly stated in the literature. The authors believe Fylling (2002), for example, invokes these assumptions and even discusses spatial correlation in the context of upscaling via Monte Carlo. These default assumptions are

- The random measurement and parameter errors in the petrophysical models have a spatially correlated and a spatially uncorrelated part.
- The spatially correlated part is taken to be perfectly correlated along the entire reservoir, consistent with an infinite correlation distance.

- The spatially uncorrelated part, having a zero-correlation distance, is then ignored because its contribution is assumed to have zero mean and variance.

The default assumptions involve assigning an extreme value to the correlation distance. This is convenient because the spatial correlation is not referenced in the analysis. However, the numerical results presented here indicate that values for upscaled petrophysical quantities depend strongly on the spatial correlation of the errors. Even though it is not straightforward to precisely characterize the spatial correlation between a pair of petrophysical errors along a reservoir, alternative characterizations of the spatial correlation had a significant impact on an upscaled results studied in this paper. Fylling (2002) also discusses using upscaled and uncertain petrophysical results in reservoir models. A meaningful discussion on populating reservoir models using upscaled and uncertain petrophysical results is not offered here because it would be lengthy and is beside the point of this paper.

Regardless of spatial correlation, when a petrophysical cutoff is used, a N/G ratio is evaluated. It represents the fractional distance along the interval being summarized over which the cutoff condition is satisfied. A petrophysical property distribution over the intervals satisfying the cutoffs is also evaluated. This paper advocates treating both the property distribution and N/G ratio as a pair of jointly distributed random variables in a statistical sense. (It can be convenient to treat the N/G as an independent variable. When this is done, it is necessary to regard the property distribution as conditional for a given N/G. The roles of the two variables can be interchanged.) Simply evaluating the N/G ratio and property distribution as if they are two independent quantities lead to larger errors in the results, particularly under the default assumptions.

Numerical examples for a 50-m thick clastic reservoir are given. The logs indicate significant heterogeneity over vertical distances of 5 to 10 m. When correlation distances in this range are used in place of the default assumptions, the P90 to P10 spread in the distributions representing the petrophysical summaries decreased by approximately 50%. Interestingly, assuming zero spatial correlation provided distributions having about 10% of the width of the corresponding distributions using the default assumptions.

The petrophysical cutoff condition used in the examples lead to: (1) the P50 Hydrocarbon Pore Fraction (*HCPF*) depending strongly on the correlation distance for a given N/G ratio; (2) a substantial underestimate of P50 reserves if petrophysical properties are treated as an independent variable instead of as a conditional variable when the default assumptions are used for a given N/G ratio; (3) a significant underestimate of proven reserves under the default assumptions; and, (4) a significant overestimate of possible reserves under the default assumptions. Effects of cross-correlations between various parameters were also underestimated by treating the petrophysical property and N/G independently.

The numerical results were evaluated using a customized Monte Carlo algorithm suited to summarize petrophysical results and amid random measurement and parameter errors with specified correlations between variables at a given depth and correlations across depths. Care was taken to treat the property distributions and N/G as jointly distributed variables. This customized algorithm also enables propagation of arbitrary, depth-dependent statistical distributions through a chain of calculations.

The next section provides a brief discussion of the types of uncertainty and errors in a petrophysical analysis studied in the examples. These are random errors associated with the measured well-log values and the parameters used to evaluate the results being summarized. Spatially correlated random errors in the context of a petrophysical summary are discussed in the section on “Spatial Correlation” along with some options for estimating spatial correlation values. A useful reference on the topic was written by Gringarten and Deutsch (2001). Correlations between random errors in the variables are discussed in the section on “Dependencies Between Variables”, which also specifies the “cross-correlation model” used here. The model is necessary to ensure that a valid covariance matrix is used in the analysis (Apanasovich and Genton, 2010). Petrophysical cutoffs are discussed in the section on “Petrophysical Cutoffs”. Statistically-characterized cutoffs are treated in detail, and so is the joint nature of the N/G and petrophysical property distributions. Later sections describe the petrophysical data and methodology, which is used in the numerical examples; and the statistical methodology, which is used to obtain numerical results for (a) cases without a petrophysical cutoff, and (b) where a shale volume (V_{sh}) cutoff is applied.

A series of guidelines for resource evaluation and classification known as the Petroleum Resources Management System (PRMS) is now being further developed under sponsorship from the American Association of Petroleum Geologists (AAPG), World Petroleum Council (WPC), the Society of Petroleum Engineers (SPE), the Society of Petroleum Evaluation Engineers (SPEE), the Society of Exploration Geophysicists (SEG), the Society of Petrophysicists and Log Analysts (SPWLA), and the European Association of Geoscientists and Engineers (EAGE). In the context of the PRMS, Monte Carlo Calculations of the type described here fall under probabilistic reserves estimation. The reserves classifications in the PRMS are 1P (proved), 2P (proved + probable), and 3P (proved + probable + possible). Results presented here map to these classifications as follows: P10↔1P, P50↔2P, and

P90↔3P. There is not a consistently-applied convention in the industry for these designations (Aldred, 2018).

UNCERTAINTY AND ERRORS IN A PETROPHYSICAL ANALYSIS

Measured data used for a petrophysical analysis typically include a set of well logs suitable for evaluating shale content, porosity, and water saturation along a reservoir interval. Results are evaluated depthbydepth, upscaled (summed or averaged), and reported in a petrophysical summary. Much has been written on the general topic of uncertainty and errors in a petrophysical analysis (Theys, 1999; Bowers and Fitz, 2000; Fylling, 2002; Verga et al., 2002; Stalheim, 2016). These references should be a good starting point for a literature review. The discussion of uncertainty and errors given here is limited to the types of errors addressed in the examples given in this paper. These are random errors associated with the measured well-log values and the parameters of the models used to evaluate the results being summarized. Examples of errors not addressed in the examples include, but are by no means limited to depth errors, sampling bias errors, and model errors.

To what extent does a random error correlate with itself or with another error over depth? This is an important, rarely asked question. In practice, the random errors are implicitly assumed (by default) to have spatially correlated and uncorrelated components. The uncorrelated part is ignored because its variance is assumed to be negligible and the correlated part is assumed to be maximally correlated. This paper reconsiders these assumptions and suggests that their use should be limited to instances where the assumptions are believed to be correct.

In addition to the well logs, parameters are required to perform a petrophysical analysis. For example, a matrix density and a fluid density are prescribed to evaluate a porosity from a density log. Archie parameters, m and n, are specified to evaluate a water saturation from a porosity and a resistivity log. The set of parameters may be determined from a combination of data sources that include cores, drill cuttings, mud logs, fluid samples, and well-test results. Adequate spatial sampling (both along a well and laterally in the field) is challenging because costs and operational difficulties of obtaining complete datasets in single wells can be prohibitive; nonetheless, a set of parameter values has to be prescribed along the reservoir to perform the analysis. Each parameter can be assigned a distribution about its mean value along the well. The spatial correlation of the parameter errors is also treated using the same default assumptions applied to the measurement errors. Petrophysical cutoffs are parameters often used in defining net reservoir thickness and property distributions. Fylling (2002) discusses issues with cutoffs and determining their value.

SPATIAL CORRELATION IN THE CONTEXT OF A PETROPHYSICAL SUMMARY

Spatial correlation between errors associated with petrophysical variables is expected because of temporal and spatial variation in depositional processes and other factors, such as diagenesis. In the vertical direction, correlation distances tend to be much smaller than in the lateral direction (Gringarten and Deutsch, 2001) because most depositional processes occur over a relatively wide lateral area but at a slow rate. This is consistent with Walther's law, which states that a vertical sequence of facies will be the product of a series of depositional environments that lay laterally adjacent to each other; also, temperatures and pressures that affect diagenetic processes and fluid properties usually vary much more vertically than laterally.

Reservoir models commonly use on lateral spatial correlation to constrain reservoir properties between wells. This paper applies such commonly-used concepts to upscale petrophysical results and their uncertainties. Given an upscaled petrophysical distribution at a well, realizations of an earth model between wells can be populated by sampling form the distribution in a way that honors the lateral spatial correlations deemed applicable by the reservoir engineer setting up the model.

In the field of statistics, spatial correlations are often characterized using an autocorrelation function. An autocorrelation is a correlation between errors for a variable at two different locations or times (in this paper, time-dependent correlations are not discussed).

Geostatisticans refer to a related quantity known as a variogram. This paper will refer to autocorrelation functions, rather than variograms, because autocorrelations relate directly to the covariance matrix used to sample the random variables. The relationship between an autocorrelation function and a variogram for a stationary variable is $2\gamma = 2\sigma^2 (1 - R)$ where the variogram is 2γ, the autocorrelation function is R, and σ^2 is the variance of the variable (the examples and methods used in this paper are not limited to stationary processes). For a more detailed discussion of variograms, refer to Gringarten and Deutsch (2001). For a petrophysical summary in a vertical well, autocorrelation functions representing measurement and parameter errors in the vertical direction are relevant. Examples published in the literature demonstrate that such spatial correlations vary significantly ranging from less than one meter to tens of meters (Gringarten and Deutsch, 2001).

The autocorrelation between a variable at depths z_1 and z_2 is $R(z_1, z_2)$. In the examples of petrophysical summaries presented in this paper, a simplified version of the autocorrelation function, $R(|z_1 - z_2|)$, is used. It depends only on the distance, $|z_1 - z_2|$, between the two depths. This simplification is a matter of convenience. It is not required to practice the statistical methodology described in the section on "Statistical Methodology."

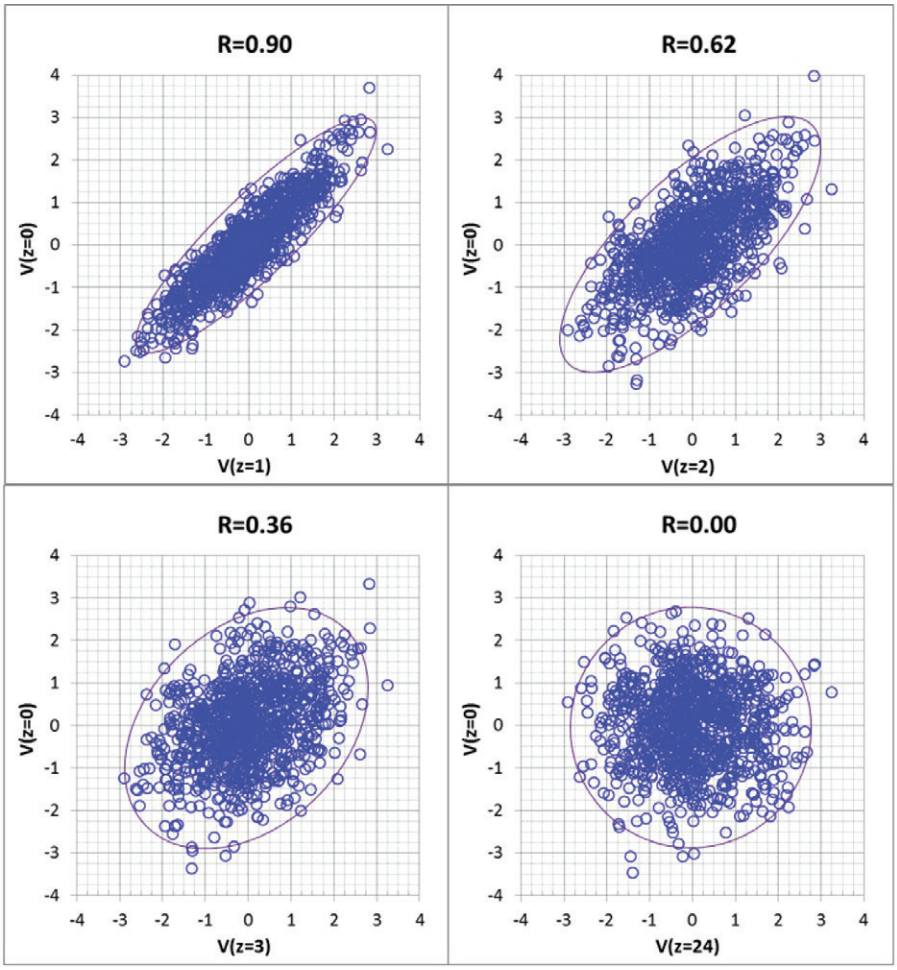


Fig. 1—Ten thousand realizations of a random variable, $V(z)$ where z = 0, plotted against itself at distances of z = 1 ft, z = 2 ft, z = 3 ft, and z = 24 ft. The autocorrelation coefficient, $R(z)$, decreases to zero over this range according to a Gaussian function with a correlation distance of 3 m.

Figure 1 shows four crossplots of 10^4 realizations of a random variable, $V(z)$, at a depth, z = 0, against itself at depths $z = 1$ ft, $z = 2$ ft, $z = 3$ ft, and $z = 24$ ft. The autocorrelation function decreases over this range according to:
$R(z) = \exp(-|^{z}/_{3}|^{2})$.

This is a Gaussian autocorrelation function with a correlation distance of 3 ft. For the depth, z = 1 ft, the autocorrelation coefficient is 0.90; accordingly, the crossplot shows a strong dependence between values of the variable at z = 0 and z = 1 ft. For longer distances, the correlation coefficient decreases, resulting in less dependence between the two sets of values for the random variable shown on the crossplot.

Figures 2a to 2c each show three realizations of random errors with correlation distances of l_c = 1.5 m, 3.0 m, and 9.0 m. As the correlation distance increases, the errors vary less rapidly along the interval. Figure 2d represents the depth-average error for each correlation distance. The distribution becomes narrower as the correlation distance decreases because the errors tend to be more independent and cancel to a greater extent when they are averaged.

Figure 3 is a schematic depicting porosity over a depth interval. A probability density function (PDF) characterizes the porosity distribution at each depth. Suppose a distribution for the depth-average of the porosity is to be evaluated. The result very much depends on how the errors vary from depth to depth. One extreme case is independent (and therefore uncorrelated) errors (i.e., $R \rightarrow 0$). The PDF for the sum of independent random variables is the mathematical convolution of the individual PDFs (Jazwinski, 1970). The convolution operation leads to a relatively narrow distribution for the average. This is expected because independent errors tend to cancel over a large number of realizations for the sum; conversely, the errors have high spatial correlation, $R \rightarrow 1$, and the distribution for the depth-average case will be wider because the errors tend to accumulate instead of cancel. The correlation coefficient for such random variables is not

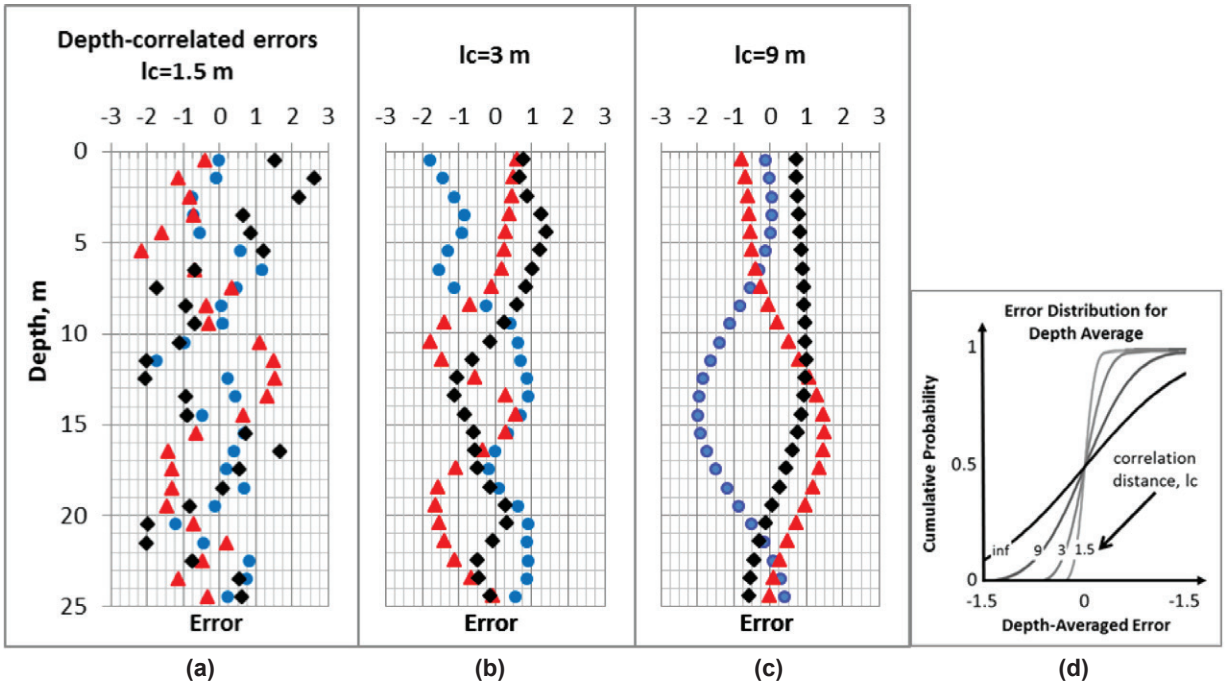


Fig. 2—Three realizations of a random error having a correlation distance of (a) 1.5 m, (b) 3.0 m, and (c) 9.0 m. A schematic representing the dependence of the distribution for the depth-average error on the correlation distance is shown in (d).

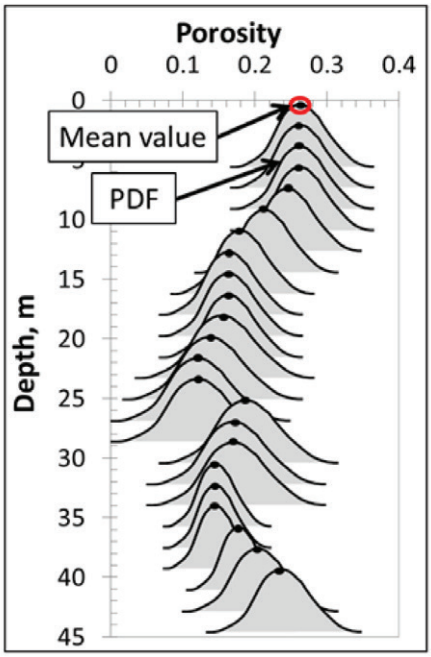


Fig. 3—This schematic depicts porosity over a depth interval. The porosity is characterized by a probability density function (PDF) at each depth. A depth-average of porosity will have a statistical distribution that depends on how the errors correlate along the interval.

guaranteed to be 1, but it will be or approach 1 in most practical cases of interest for the purpose of this paper.

It is unlikely for errors to have nearly perfect spatial correlation or to be totally independent; however, it can be convenient to represent uncertainties as having a wider distribution (as is the case for) instead of a narrower distribution to increase the likelihood that actual values for the petrophysical summary is within the predicted limits. This practice can cause collateral damage. For example, a risk-neutral operator (seeking a maximum return for a given uncertainty level across a portfolio of investments) will require higher-than-necessary returns given overstated uncertainties. A risk-averse operator may avoid an investment based on a petrophysical result indicative of a risk higher than there actually is. A risk-tolerant operator may make bad investments based upon inflated expectations for the upside. This paper is written assuming that a petrophysical summary is more valuable when it is evaluated using the correct uncertainties.

Estimating Spatial Correlations

The default assumption for spatial correlation is an extreme value, , for spatial correlation and applying it uniformly in the analysis. It is very likely that one can do better even lacking sufficient data to directly evaluate spatial correlations using a formal procedure like the one Gringarten and Deutch (2001) describe. When sufficient data are unavailable to simply evaluate the autocorrelation or variogram according to mathematical definitions, a geological understanding of the scales and severity of various heterogeneities in the reservoir

are important. Vertical scales may vary from a few decimeters up to the thickness of the reservoir. Once the scales for a heterogeneity are determined, the question is how much does an error decorrelate over such a scale? This is partly a geological question. It is likely to lead to a few scenarios to include in the calculations, but it can also point to the need for acquiring more core or using digitally evaluated rock properties, both of which can improve the accuracy of the estimated correlations. In the examples presented herein this paper, the default assumptions are replaced by uniformly applying a finite correlation distance in the calculations instead of an infinite correlation distance. This was done to keep the examples simple and make them more instructive.

Examples of more complicated spatial correlation scenarios that could be treated in a subsequent publication include lithological uncertainty and independent geological units. In the case of lithological uncertainty, a different set of spatial correlation parameters may be prescribed for each lithology considered. In fact, the lithology may have its own spatially correlated uncertainty, within which each lithofacies may be characterized with its own set of spatial error correlations.

Even simple cases with independent geological units may be worthy of separate publication. Consider a pair of geologically-independent reservoir units. Suppose one applied the method described in this paper to upscale a petrophysical property and its uncertainty for each of the two geological units. Given that the units are independent, the PDF for a petrophysical property representing the composite (both units together) is the convolution of the individual PDFs (Jazwinski, 1970).

DEPENDENCIES BETWEEN VARIABLES

Dependencies between variables are also important. Causes for such dependencies include (1) two variables depending on a third, (2) two variables resulting from or being influenced by a common process; and, (3) the existence of a causal relationship between variables. For sedimentary rock, all of these may be relevant because the properties of the rock are the result of a common depositional process and geological history. In a petrophysical analysis, results are evaluated using a chain of calculations. This means that a result can be correlated with the measurements and parameters used to evaluate it and also with other results that depend explicitly (or implicitly due to another correlation) on a common measurement or parameter.

A cross-correlation coefficient can be assigned to each pair of variables and used to characterize the correlation between their errors at a given depth. In general, this methodology includes cross-correlations that vary with depth. For convenience, the cross-correlations are taken to be constant along the well.

A dependency between the mean values of variables is different than a dependency between their errors. Relationships between mean values are applied to determine a "log" representing the mean values along the well. The errors are then superimposed on the mean values.

Errors for different variables across depths are not generally independent because of autocorrelations and cross-correlations. This is because a valid covariance matrix must be non-negative definite. In this paper, a "separable model" is used to relate the correlations between different variables across depths. In a separable model, the auto and cross-correlations are specified independently and combined in a multiplicative process. Separable and other models are discussed in the literature (Apanasovich and Genton, 2010).

To specify the separable model used in the numerical examples, let the cross-correlation coefficient for variables *i* and *j* be $r_{ij}(0)$. The correlation coefficient applicable between variable *i* at the depth Z_1 and variable *j* at depth z_2 is:

$$r_{ij}(|z_1 - z_2|) = r_{ij}(0)\sqrt{R_i(|z_1 - z_2|)R_j(|z_1 - z_2|)}\,, \qquad (1)$$

where $R_i(|z_1 - z_2|)$ and $R_j(|z_1 - z|)$ represent the autocorrelation functions for the two variables. Equation 1 is a useful model because it provides a simple way of specifying a valid correlation matrix consistent with the inputs. It amounts to geometrically averaging the autocorrelation functions for each pair of variables.

Estimating Cross-Correlations

The remarks at the end of the previous section suggest some alternatives for evaluating correlation distances (autocorrelation functions). Challenges are similar in the evaluation of cross-correlations when there are insufficient data to evaluate them according to their mathematical definitions. One should keep in mind that an assumption is made by assigning a trivial value (such as zero) to a cross-correlation. Using such assumptions without careful consideration is potentially more dangerous than using a qualitatively estimated, nontrivial value for a cross-correlation. There is a high likelihood that a petrophysical summary can be improved or defended by (1) estimating the error for each variable using existing data, (2) identifying data that may be used to numerically evaluate correlations between variables, (3) identifying geological reasons as to why a correlation between two variables may exist or not, and, (4) attempting to bound the range for the correlation coefficient based on geological reasoning, reservoir performance, etc.

PETROPHYSICAL CUTOFFS

Cutoff conditions may be used to eliminate intervals corresponding to poor-quality rock or reservoir having insufficient porosity or a high shale content. Depth intervals satisfying the cutoff condition are included in a N/G ratio (i.e., N/G = net thickness/gross thickness) distribution. Property distributions [such as porosity, water saturation, shale volume (V_{sh}), permeability, etc.] are evaluated over the population of results that satisfies the cutoff condition. A cutoff condition can have its own autocorrelation function and it can be correlated with other variables.

Figure 4 is an example of a constant and deterministic cutoff condition applied to a variable with a mean value of zero at each depth. A depth interval with an error below the cutoff is excluded from the N/G distribution. The correlation distance in Fig. 4a is infinite; so, all values in any given realization either pass or fail the cutoff. This leads to the step distribution for N/G as shown in Fig. 4c. Figure 4b shows the correlation distance being 3 m. Some values pass and others fail in any given realization. This leads to a continuously valued distribution.

Cutoff conditions can be estimated based on reservoir performance, geological analogs, or core data. Often, the parts of a reservoir that will perform poorly have more complicated petrophysical relationships than the most relevant portion of the reservoir. One use of a cutoff is to avoid errors from applying petrophysical models suitable for the most relevant parts of the reservoir to intervals of lesser value. Of course, there is some uncertainty in the delineation of these intervals; thus, determining a suitable value for a cutoff can be a challenge. This is one reason why a statistically-defined cutoff can be useful (Fig. 5). This cutoff condition may or may not be satisfied in any realization at each depth in the range. Each realization is dependent on the property value error and the value for the cutoff, both of which can vary along the interval. In this example, intervals with a higher mean porosity will satisfy the cutoff more frequently than intervals with a lower mean porosity.

When a petrophysical property distribution is evaluated using a cutoff condition, it is a conditional distribution that depends on N/G. Consider a population of N/G and corresponding net-average petrophysical property values. Each member of the population is a pair of values that was evaluated together. They are not generally independent. Over the population, for any given N/G-value, there is a range of net-average petrophysical property values. For another N/G-value, the net-average petrophysical property distribution will generally be different; similarly, for any given net-average petrophysical property value, there is a range of N/G values that will vary with the net-average petrophysical property value. For this reason, both variables are characterized with

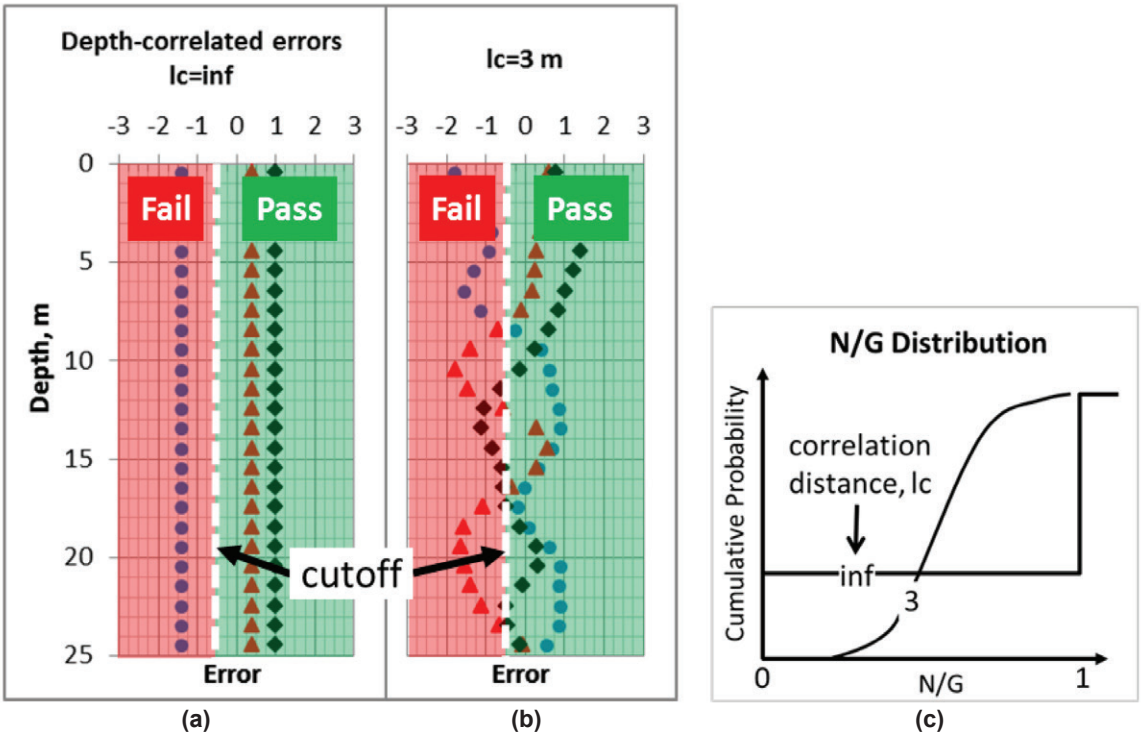


Fig. 4—Two realizations of a random error with a correlation distance of (a) infinity and (b) 3.0 m. The cutoff condition is also shown. For the case with the infinite correlation distance, all values in any given realization either pass or fail the cutoff. This leads to the step distribution for N/G shown in (c). For the case with the 3 m correlation distance, some values pass and others fail in any given realization and leads to a narrower distribution (c).

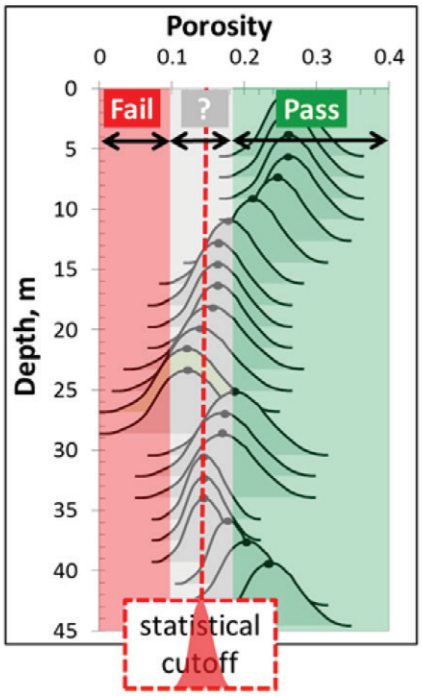


Fig. 5—This schematic is analogous to Fig. 4, but the cutoff condition is statistically defined and all properties of the variable are depth-dependent.

a two-dimensional (2D) joint PDF. The N/G will be treated, by convention, as an independent variable. A conditional netaverage petrophysical property distribution will then be applicable for a given N/G value.

Figures 6 and 7 shown below are examples of results evaluated using the data and methodology described in the sections on "Petrophysical Methodology" and "Statistical Methodology." The cutoff condition is a shale volume cutoff (V_{sh_c}) with a mean value of 0.5 and standard deviation of 0.1. Figure 6 is a set of 2D histograms representing the joint PDF for a population of N/G and the corresponding net-average shale volume (V_{sh} Net) values evaluated for correlation distances, l_c = 0, 1.5, 3, 6, 12, 24, 48 and ∞ m. The cross-correlation between the errors for the V_{sh} and the V_{sh_c} is zero in each graph. It is evident, especially from the results with larger correlation distances, that N/G and V_{sh} Net are dependent. If they were independent, the variation along one axis would not depend on the value on the other. One may wonder why, in Fig. 6, the maximum value for V_{sh} Net is < 0.5 given that the cutoff condition has a mean value of 0.5. This is because the V_{sh} Net values are an average shale volume over only the depths that passed the cutoff in each realization.

Figure 7 is a quantitative comparison of the P50 property distributions evaluated jointly and independently. Results for three cases with different cross-correlation values (0, -1, +1) between the errors for the V_{sh} and the V_{sh_c} are shown as a function of the correlation distance. For reference, each graph has a point for the "Uncertainty Neglected" case where calculations were done without reference to any uncertainty. There are geological reasons why the correlation between errors for the V_{sh} and the V_{sh_c} may be positive or negative. Suppose, for example, the shale volume has dispersed and laminated components. A negative correlation is appropriate for V_{sh} errors dominated by the dispersed component because its increase has a larger adverse impact on reservoir performance than an equivalent increase in the laminated component. A positive correlation would be appropriate for V_{sh} errors dominated by variations in the laminated component because of a larger V_{sh} in an otherwise equivalent laminated reservoir.

The N/G results shown in Fig. 7a are applicable to both the jointly and independently evaluated property distributions because N/G is treated as the independent variable in the conditional relationship between the net-average property and the N/G values. Neglecting uncertainty leads to underestimating the N/G by up to 6% when the correlation distance is infinite. For zero correlation distance, neglecting uncertainty overestimates the N/G by about 9%. The N/G ratio scales property distributions that represent volumes such as a porosity, bulk volume water, and *HCPF*; therefore, each vertical axis in Figs. 7b to 7e is the property value multiplied by N/G. This scaling accounts for the fact that 1−N/G of the total rock volume has been removed by the cutoff condition and enables comparison of results across a range of N/G values on a per unit volume basis.

Figures 7b and 7c are the net-average effective porosity scaled by N/G and evaluated respectively using joint and independent distributions. For an infinite correlation distance, the porosities from the joint distribution would be underestimated by 5 to 15% when neglecting uncertainty. When the correlation distance is zero, a 5 to 10% overestimate of the porosity would result from neglecting uncertainty. The corresponding results from the independent distributions in Fig. 7c are almost the same as from the joint distribution when the correlation between the V_{sh} and the V_{sh_c} errors is +1. The uncorrelated and negatively correlated cases are significantly underestimated when the correlation distance is large and independent distributions are used. The results from the joint and independent distributions are nearly the same when the correlation distance is zero. Similar remarks apply for the *HCPF* values in Figs. 7d and 7e. If the correlation distance is large, neglecting uncertainty would lead to underestimating hydrocarbon reserves by between 13 and 29%. Estimating the reserves using independent distributions gives a roughly 15% underestimate of hydrocarbon reserves.

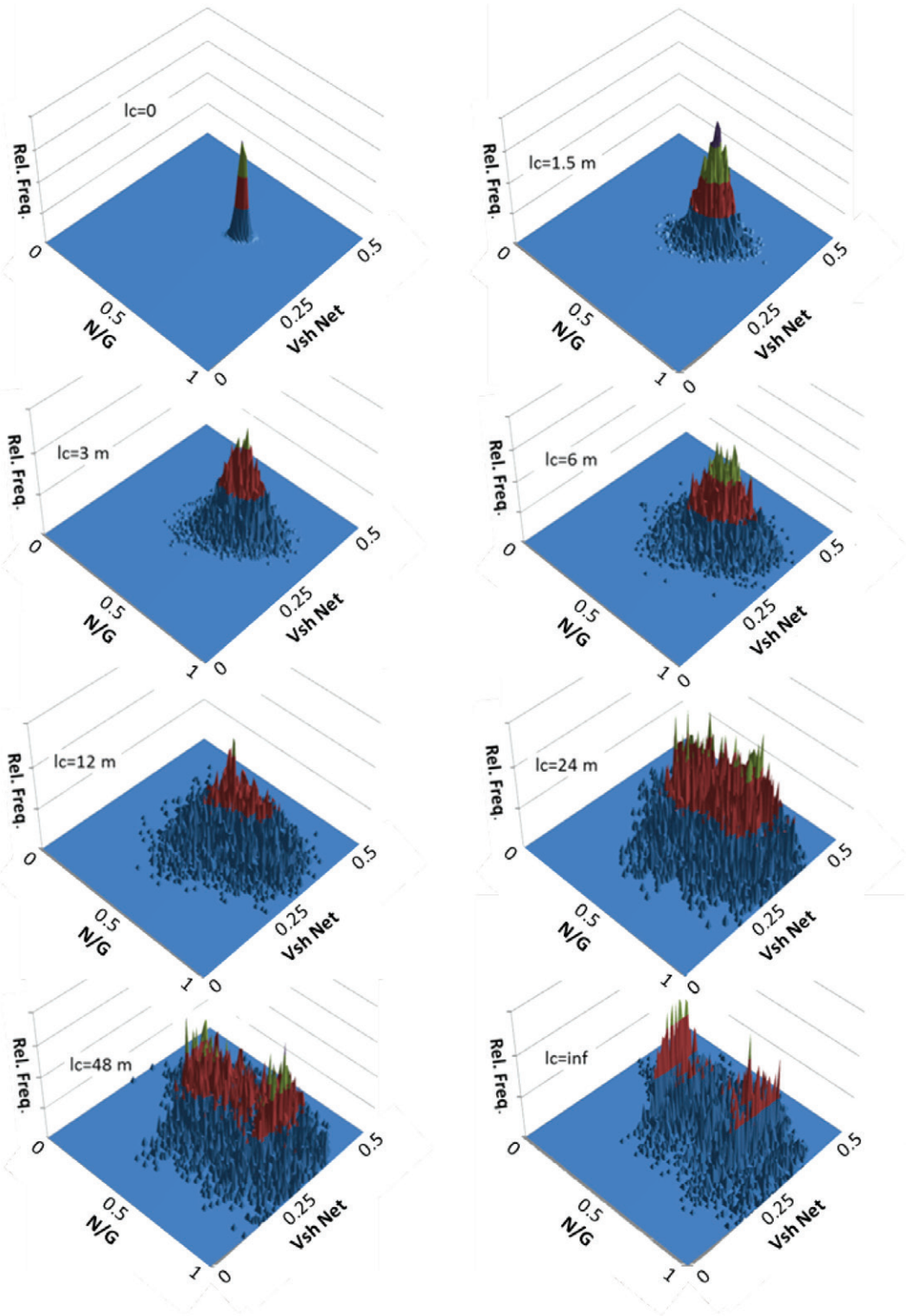


Fig. 6—Two-dimensional histograms representing joint PDF for net-average V_{sh} and N/G. The V_{sh_c} has a mean value of 0.5 and a standard deviation of 0.1. Cases for correlation distances of l_c = 0, 1.5, 3, 6, 12, 24, 48 and ∞ m are shown.

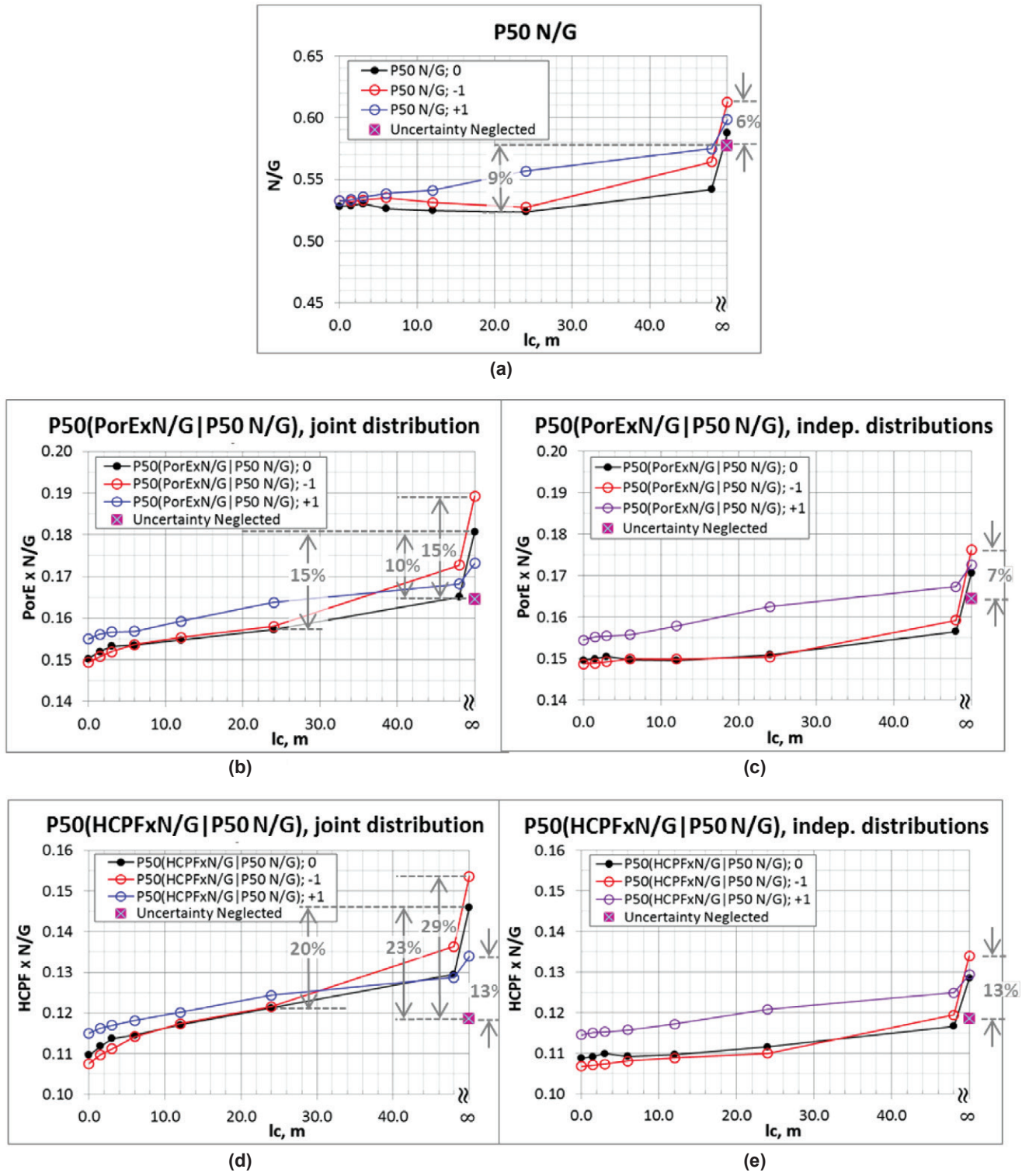


Fig. 7—The P50 N/G is plotted in (a). The median for the net-average effective porosity and hydrocarbon pore fraction (*HCPF*) \results were evaluated using a joint distribution in (b) and (d) given the P50 N/G. The same results evaluated assuming independent distributions are shown in (c) and (e). Each graph also has a point corresponding to the "Uncertainty Neglected" case.

In this example, neglecting uncertainty leads to a significant underestimate of P50 porosity and hydrocarbon reserves when correlation distances are large; and a significant overestimate the same results when correlation distances are small. Comparing results from joint and independent distributions leads to the conclusion that the use of joint distributions and conditional probabilities to estimate property values makes a substantial difference when correlation distances are large but has little impact when correlation distances are small. Based on these results, it appears to be worthwhile to account for autocorrelations, cross-correlations, and to estimate property values on the basis of joint distributions when cutoffs are used, especially when correlation distances are large.

There has been an ongoing debate over the use of cutoff conditions in general, as well as the use of any specific instance of a cutoff condition. This paper does not advocate using or avoiding cutoffs and provides examples with and without cutoffs. Reference to cutoffs made here is to state that, if cutoffs are used, their correlation to other properties and their spatial correlation need to be considered. It is clear from the examples that the effect of a cutoff condition is the most when the default assumptions are applied.

How the shale volume cutoff used in these examples was determined is beside the point of this paper. However, it was evaluated by plotting cumulative*HCPF* against the corresponding shale volume in a simplified calculation that ignores uncertainty. The "knee" on this curve is close to V_{sh} = 0.5 and corresponds to a cumulative *HCPF* of 0.90. The mean value for the cutoff condition was assigned a value of V_{sh_c} as a result. The standard deviation assigned to the cutoff condition is conservative in that it is less than the uncertainty in the V_{sh}. One may argue that the cutoff V_{sh_c} = 0.5 is high; however, lowering the value would increase the influence of the cutoff on the results. One may then argue that alternative methods should be used to evaluate the shale volume, but the methodologies used here are consistent with previously published methods accepted by the SPWLA in Stalhiem (2016).

In general, the authors advocate avoiding shale volume cutoffs in laminated formations. In such cases, ideally, any cutoff condition that is to be applied would be based on a sand count and sand layer properties. The authors have no reason to believe the formation evaluated in this paper is laminated and consider this cutoff condition to be defensible.

PETROPHYSICAL METHODOLOGY AND HYDROCARBON INITIALLY IN PLACE

The well-log data, petrophysical methodology, error distributions, and correlations from Stalheim (2016) are honored here.

Shale volume $$V_{sh} = \frac{GR - GR_{sa}}{GR_{sh} - GR_{sa}}, \quad (2)$$

Total porosity $$\phi_t = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f}, \quad (3)$$

Effective porosity $$\phi_e = \phi_t - V_{sh}\phi_{sh}, \quad (4)$$

Water saturation $$S_w = \left[\frac{R_w}{R_t} \cdot \frac{R_{sh}}{\left(VSH^{1-VSH/2} \cdot \sqrt{R_w} + \phi_e^{m/2} \cdot \sqrt{R_{sh}} \right)^2} \right]^{1/n}, \quad (5)$$

Hydrocarbon Pore Fraction $$HCPF = \phi_e(1 - S_w). \quad (6)$$

where in Eq. 2, V_{sh} is shale volume, *GR* is the measured gamma ray log value, GR_{sa} is *GR* in a pure sand formation, and GR_{sh} is *GR* in a pure shale formation. In Eq. 3, ϕ_t is total porosity, ρ_b is the measured bulk density log value, ρ_{ma} is the matrix density, and ρ_f is the fluid density. In Eq. 4, ϕ_e is effective porosity, and ϕ_{sh} is shale porosity. In Eq. 5, S_w is water saturation, R_t is resistivity log value, R_w is water resistivity, R_{sh} is shale resistivity, *m* is the Archie cementation exponent, and *n* is the Archie. Saturation exponent.

Equation 5 is known as the Indonesia equation and is used in this paper to enable comparison of the results against results in other publications where this equation was used. Elements therein are: water saturation resistivity log value. The authors do not advocate or agree with the use of this equation for petrophysical evaluation, but further discussion of advantages and disadvantages of various petrophysical models is beyond the purpose of this paper.

The logs over the reservoir interval are shown in Fig. 8. This is a clastic reservoir with some coal and calcite beds (that were excluded from the petrophysical summaries presented here). Table 1 lists distributions for the parameters and for the measurement errors that will be used. These have been chosen to be consistent with the ranges used by Stalheim (2016). Furthermore, the data and petrophysical methodologies shown and described above were peer-reviewed and published in the *Petrophysics* for a closely related topic; so, the authors of the this paper consider these data suitable for the purpose at hand, which is to illustrate the use of a more sophisticated upscaling algorithm than was previously applied to the same data.

Figure 9 shows the beta-function Probability Density Functions (PDFs) and corresponding Cumulative Distribution Functions (CDFs) for parameters that will be characterized using a beta PDF. The beta function is versatile in the sense that it can be used to represent a wide range of symmetric and asymmetric distributions over a finite interval.

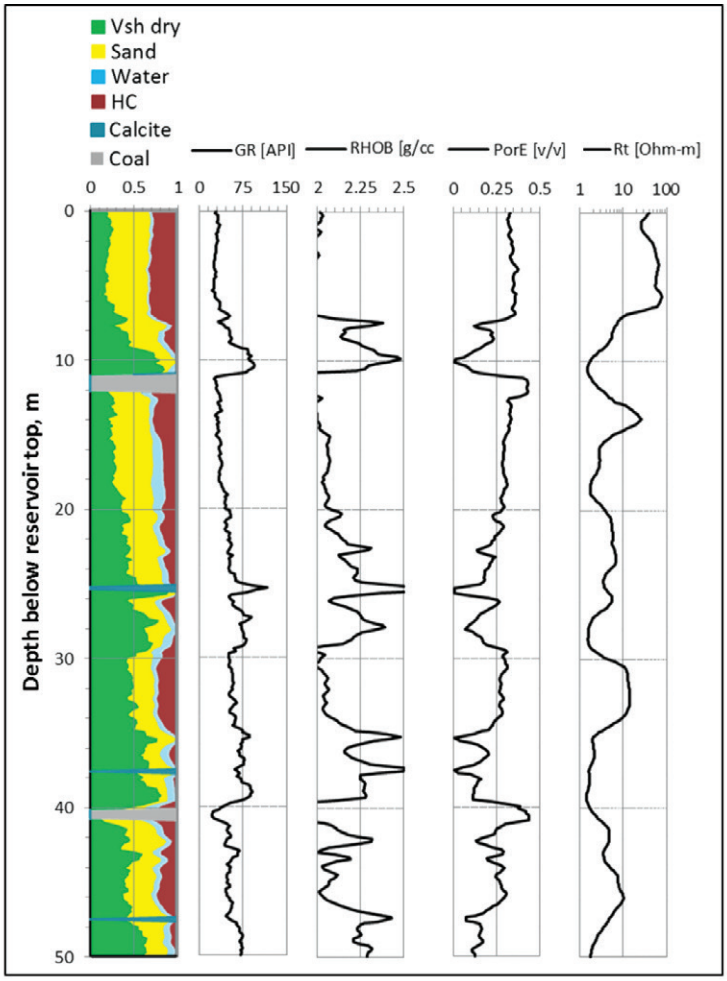


Fig. 8—Log plot over the interval of interest. Track 1, lithology; Track 2, gamma-ray (*GR*) log; Track 3, bulk density; Track 4, total porosity (ϕ_t) evaluated using mean values for log and parameter errors; Track 5, deep resistivity log.

Table 1—Distributions for Errors on Each Variable

Variable	Mean	Median	Standard Deviation	Minimum	Maximum	Unit	PDF
ρ_b	ρ_b	ρ_b	0.015	---	---	g/cm^3	normal
ρ_{ma}	2.65	2.65	0.030	---	---	g/cm^3	normal
ρ_f	0.81	0.81	0.10	---	---	g/cm^3	normal
R_t	R_t	R_t	$0.10 \cdot R_t$	---	---	$\Omega \cdot$ m	log-normal
R_w	0.073	0.073	0.0080	---	---	$\Omega \cdot$ m	normal
m	1.80	1.80	0.20	---	---	---	normal
n	2.00	2.00	0.20	---	---	---	normal
GR	GR	GR	$0.10 \cdot GR$	---	---	API	log-normal
GR_{sa}	12.5	9.8	10	0	100	API	beta
GR_{sh}	100	100	30	---	---	API	normal
ϕ_{sh}	0.10	0.10	0.05	0	0.20	v/v	beta
R_{sh}	4.0	3.74	2.00	0.10	15	$\Omega \cdot$ m	beta
$V_{\mathrm{sh\_c}}$	0.50	0.50	0.10	---	---	v/v	normal

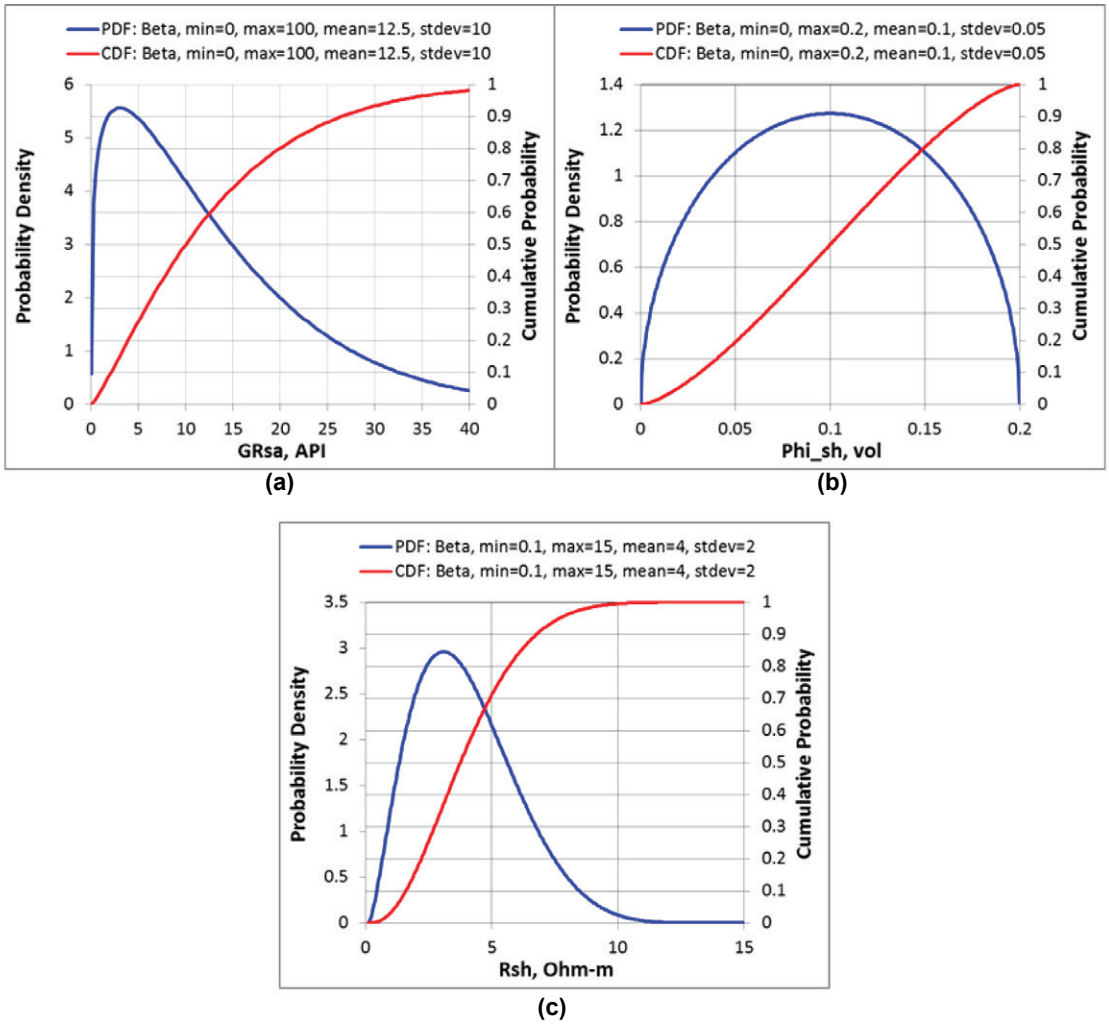


Fig. 9—Probability density and cumulative distribution functions for parameters characterized by a beta PDF. (a) GR_{sa} is the sand gamma ray value; (b) ϕ_{sh} is the shale porosity; (c) R_{sh} is the shale resistivity.

For volumetrics, the hydrocarbon pore fraction (*HCPF*) (Eq. 6) must be multiplied by a N/G ratio when a cutoff is used. In addition, a gross rock volume (*GRV*) and formation volume factor (*FVF*) respectively account for the size of the reservoir and differences between the hydrocarbon volumes at surface and subsurface conditions. Given these definitions, the hydrocarbon initially in place, *HCIIP*, is:

$$HCIIP = GRV \times \mathrm{N/G} \times HCPF \times FVF^{-1} \quad (7)$$

Proven, probable, and possible reserves are the P10, P50, and P90 values for *HCIIP* respectively. The numerical examples presented in later sections examine the factor *HCPF* × N/G in detail. This includes additional discussion of properly treating N/G and *HCPF* as a pair of jointly-distributed random variables. Uncertainty *GRV* or *FVF* should be treated carefully. Even in the simplest case where *GRV* and *FVF* are statistically independent with respect to the other variables in Eq. 7, a correct statistical calculation requires evaluating the probability distribution of a product of several random variables. The Monte Carlo algorithm discussed in the section on "Statistical Methodology" is capable of evaluating Eq. 7 even in cases where *GRV* and *FVF* are dependent. Dependencies between *GRV*, *FVF*, and the other factors in Eq. 7 are possible. Two examples where such dependencies have potential to be relevant are (1) coupling between *HCPF* and *FVF* due to temperature uncertainty, and (2) *FVF* and *GRV* due to uncertainty in the pressure (or hydrocarbon type) caused by structural uncertainties.

STATISTICAL METHODOLOGY

A set of variables comprising well logs and parameters is the primary input. Each variable is characterized using a univariate (marginal) PDF at each depth, an autocorrelation

function, and crosscorrelations with other variables. In the examples, each autocorrelation function is parameterized in distance as discussed in the section on "Spatial Correlation." The cross-correlations are taken to be constant along the well as mentioned in the section on "Dependencies Between Variables" and Eq. 1 is used to evaluate correlations between different variables across depths. See the "Variables and Statistical Inputs" boxes in Fig. 10.

Samples for the variables obeying the prescribed statistics are evaluated as follows:

1. Adjust the input correlations to be consistent with standard normal random variables using a Gaussian copula (Liu, 1986; Tang, 2015; Vorechovsky, 2008). This ensures that the samples have the correct correlation coefficients after applying the probability transformations in item 3 below.
2. Evaluate a population of the correlated standard normal random variables using a Cholesky decomposition technique (Higham, 1990). The size of the matrix that is decomposed is the number of depths in the calculation multiplied by the number of variables. Calculations for variables not correlated with each other can be done separately; so, the calculations are numerically tractable. Larger covariance matrices than can be handled with the Cholesky method can be treated using Fourier methods, but these require regularly sampled data and have other limitations undesirable for the petrophysical problem (Ravelec et al., 2000).
3. Apply probability transformations to the standard normal samples so that the probability-transformed samples have the marginal PDF that was assigned.
4. Each member of a variable population consists of a set of values corresponding for the variable at each depth.

A result population follows from evaluating functions, e.g., Eqs. 2 to 6, of the variables. Each member of a result population consists of a set of values for the result at each depth under consideration. Given a result population, one can evaluate statistical distributions for the result or quantities such as sums or averages over depth (Fig. 10).

In the examples presented here, depth-dependent distributions for shale volume (V_{sh}) and total porosity (ϕ_t) are evaluated separately. These results are used as inputs into a second calculation, which is the evaluation of depth-dependent distributions for effective porosity (ϕ_e), water saturation (S_w), hydrocarbon pore fraction (*HCPF*), and the distributions for the petrophysical summaries.

Grouping the calculations this way avoids complications arising from using a result as an input to a subsequent calculation; specifically, a large number of numerically evaluated correlations between the result and the input would have to be evaluated and carried forward into the subsequent calculation. The situation is similar for two or more results with any dependency on a common variable.

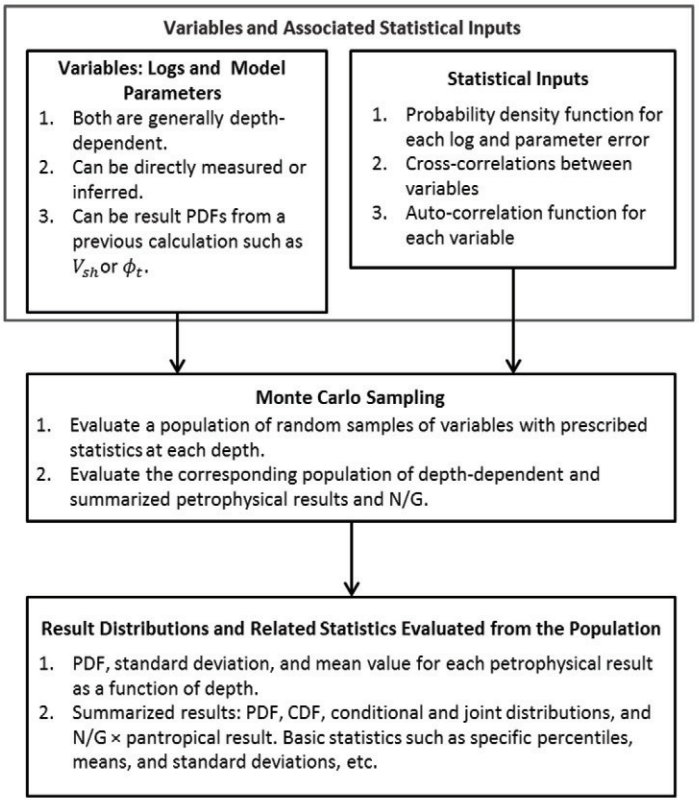


Fig. 10—Flow chart (abbreviated) illustrating the inputs and results.

EXAMPLES WITHOUT PETROPHYSICAL CUTOFFS

The petrophysical and statistical methodologies discussed in the two previous sections are applied to the data shown in Fig. 8 using inputs listed in Table 1. The autocorrelation functions shown in Fig. 11 will be used to represent the decorrelation of each error with distance. These are Gaussian autocorrelation functions, . Each autocorrelation function has a value of 1 at a distance of 0 and is required because this is a degenerate case where a variable is correlated against itself at a single location.

Figure 12 shows the mean value and PDF as a function of depth below reservoir top for shale volume (V_{sh}), total porosity (ϕ_t), effective porosity (ϕ_e), water saturation (S_w), and hydrocarbon pore fraction (*HCPF*) alongside the lithology column. These results are based on a population of 10^4. The PDF at each depth is independent of the spatial correlation but does depend on cross-correlations. In this example, the only nonzero cross-correlation is between the errors in the Archie parameters, which are taken to be perfectly correlated. This

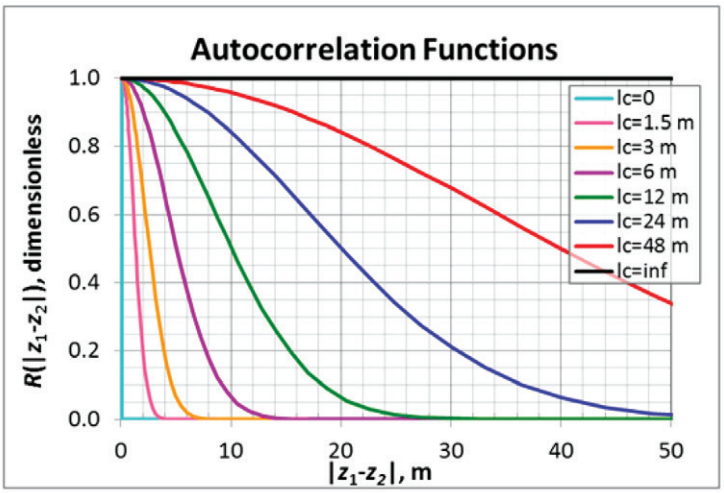


Fig. 11—Autocorrelation functions used in the examples have correlation distances ranging from zero to infinity.

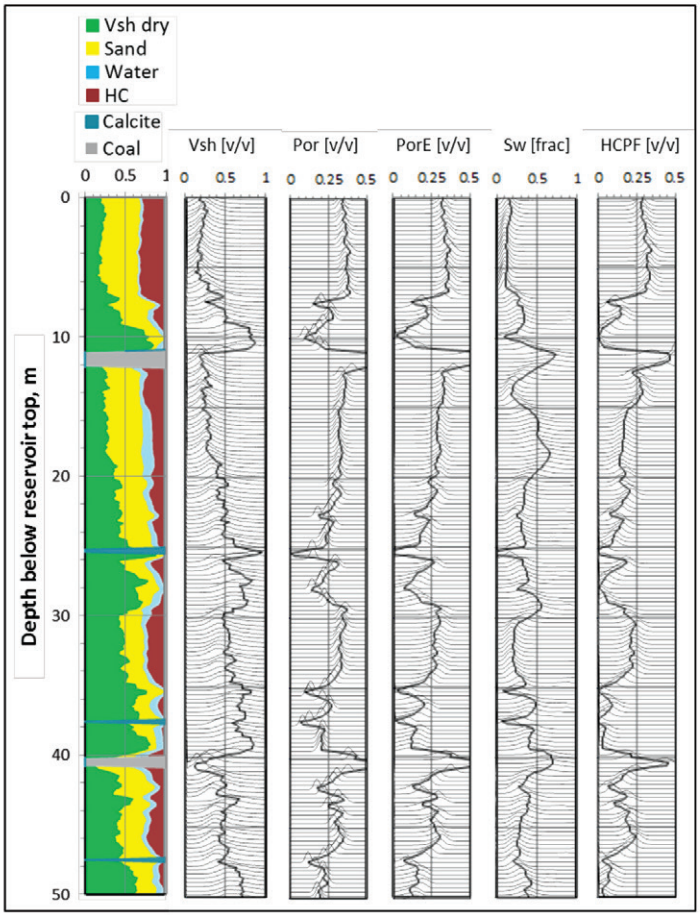


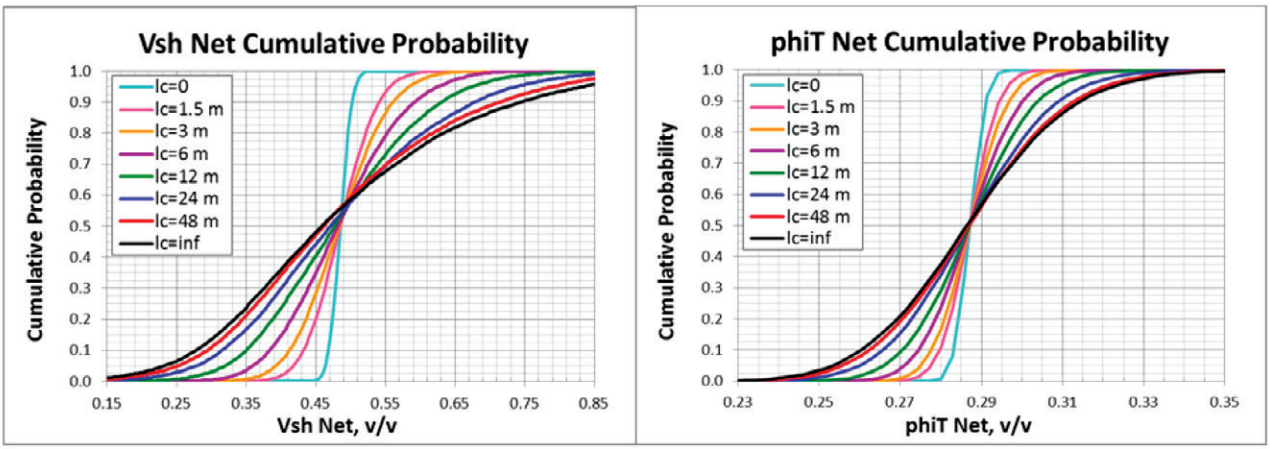
Fig. 12—Lithology column and depth-related results for shale volume (V_{sh}), porosity (Por), effective porosity (ϕ_e), water saturation (S_w), and hydrocarbon pore fraction (*HCPF*). Each track containing a numerical result shows a mean value curve and probability density.

leads to the PDFs for S_w and *HCPF* being wider (corresponding to a slightly larger standard deviation) than they would have if the cross-correlation were zero.

Figure 13 shows the cumulative distribution for the net average (average over depth) of each quantity in Fig. 12 for correlation distances of l_c = 0, 1.5, 3, 6, 12, 24, 48, and ∞ m. In all cases, the distribution becomes wider as the correlation distance increases. The net-average V_{sh} distribution is skewed toward lower values when l_c is large because (1) parts of the reservoir have a significant probability of zero shale content, and (2) when the correlation distance is large, these parts of the reservoir tend to contribute to the population of net averages as a unit (they are all zero sometimes). For smaller correlation distances, these parts of the reservoir contribute to the population of net averages more independently instead of as a unit. The net-average ϕ_t distributions (Fig. 13b) are not skewed in this fashion and the P50 value is nearly the same regardless of the correlation distance. The ϕ_e, S_w, and *HCPF* in Figs. 13c to 13e all depend on V_{sh}; so, they are similarly skewed. The effect of the correlated Archie parameter errors on the net-average distributions for S_w and *HCPF* is greater when the correlation distance is larger than when the correlation distance is smaller. The effect of this correlation is also greater on S_w than on *HCPF* because about 1/3 of the sensitivity of *HCPF* is due to ϕ_e and the rest is due to S_w.

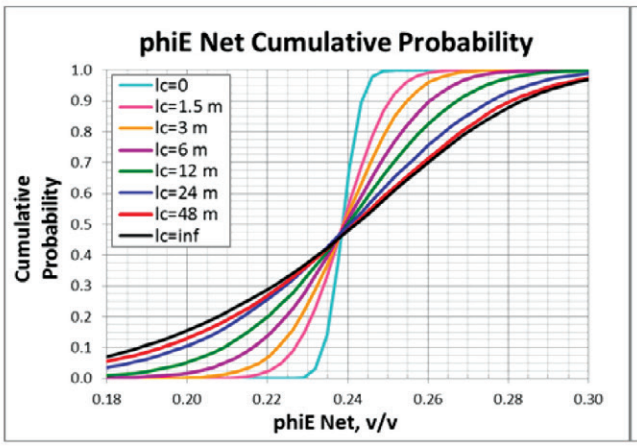
Figure 14 shows the mean value, standard deviation, P10, P15, P32.5, P50, P67.5, P85, and P90 derived from the distributions in Fig. 13 as a function of the correlation distance. Table 2 lists, as a percentage, the ratio of the standard deviation to the mean value of each result when l_c = 0.6 and m. Roughly speaking, the spread doubles as l_c ranges from 6 to m. For a thicker reservoir, the spread would increase more dramatically over this range of correlation distances. The opposite would be true for a thinner reservoir. The spread for l_c = 0 is not zero and would become relatively larger for a thinner reservoir and smaller for a thicker reservoir.

Figure 15 illustrates the dependence of the cumulative distribution for net-average *HCPF* on additional error correlations, under the default assumptions. The ϕ_t and V_{sh} errors are perfectly-correlated (long-dash line), uncorrelated (solid line), and anticorrelated (short-dash line). (Any of these cases can be realistic depending on how anomalies in the shale volume affects the matrix density, fluid density, and (even) the bulk density errors.) Consistent with the observation and discussion of the skewed results in Fig. 13, these curves do not intersect at their P50 values and differ by about 6.5%. In general, one should not expect a correct P50 result under the default assumptions even when no cutoffs are used.

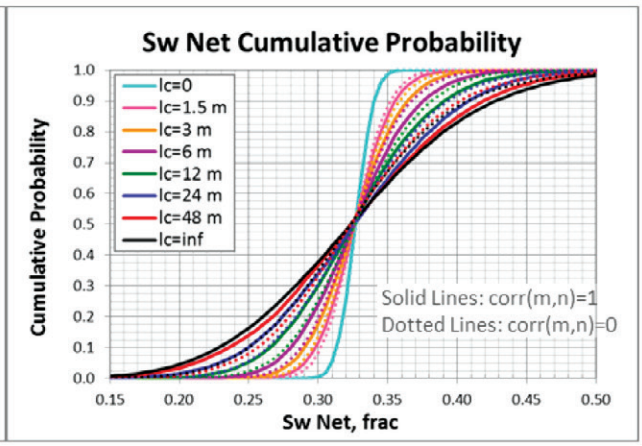


(a)

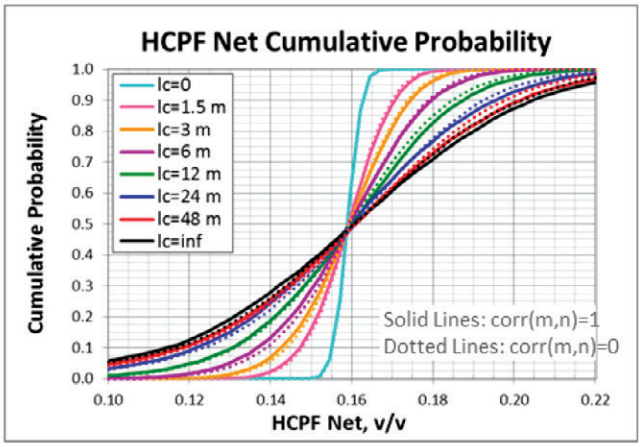
(b)



(c)



(d)



(e)

Fig. 13—Cumulative probability representing the net average for each result in Fig. 12 for the indicated correlation distances. The dotted lines on the graphs for the water saturation (S_w) (d) and *HCPF* (e) represent the case with uncorrelated errors on the Archie parameters.

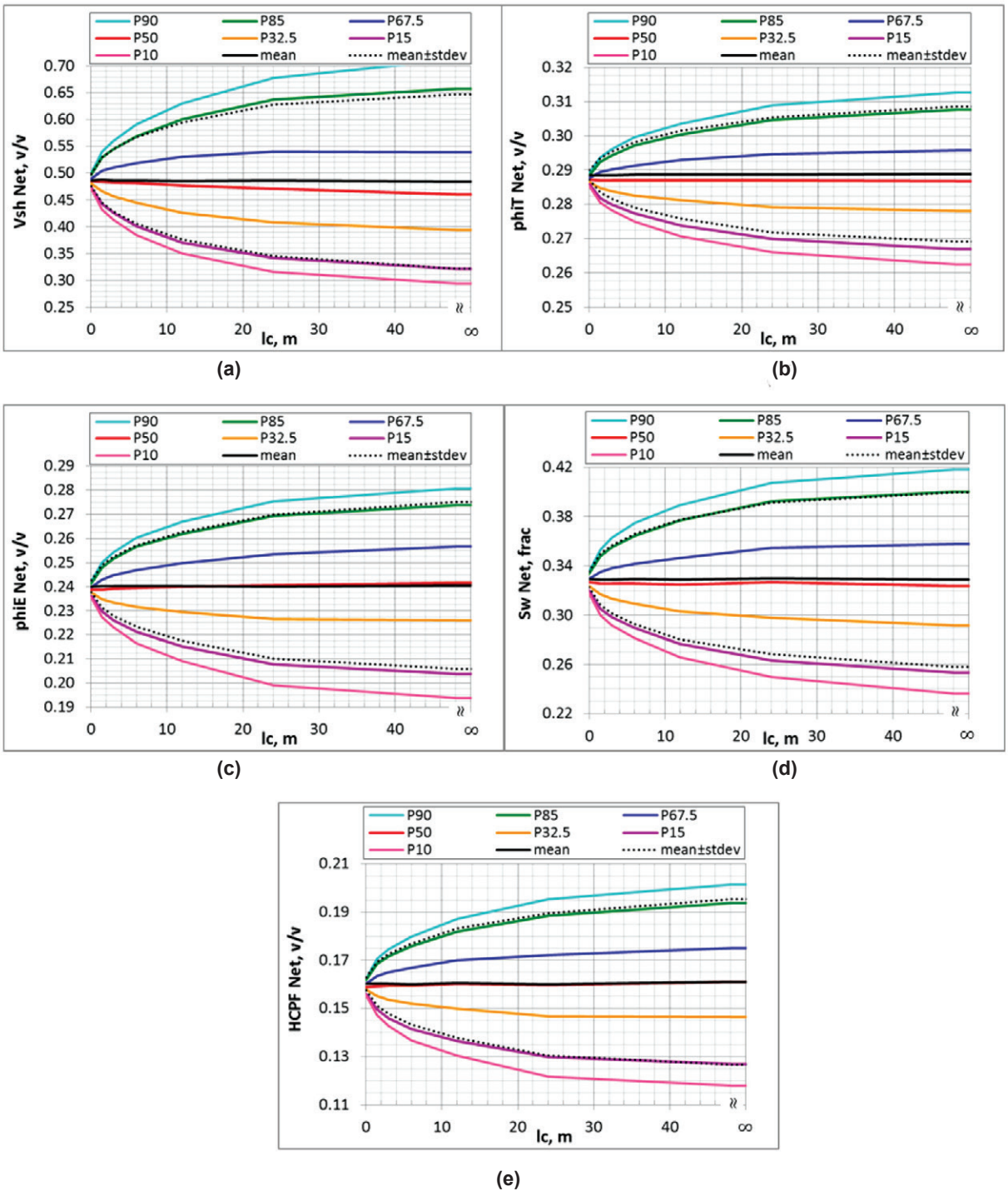


Fig. 14—Statistics for summarized quantities as a function of correlation distance.

Table 2—Ratio of Standard Deviation to Mean Value for Correlation Distances of 0 m, 6 m, and Infinity for Each Result

Variable	Stdev/Mean (%)		
	l_c = 0	l_c = 6 m	l_c= ∞
V_{sh}	2.0	16	37
ϕ_t	0.50	3.0	7.0
ϕ_e	1.0	7.0	16
S_w	1.9, 1.8	11, 9	24, 20
HCPF	1.6, 1.6	11, 10	24, 23

A pair of values is reported for S_w and *HCPF* to represent cases with correlated and uncorrelated Archie parameter errors.

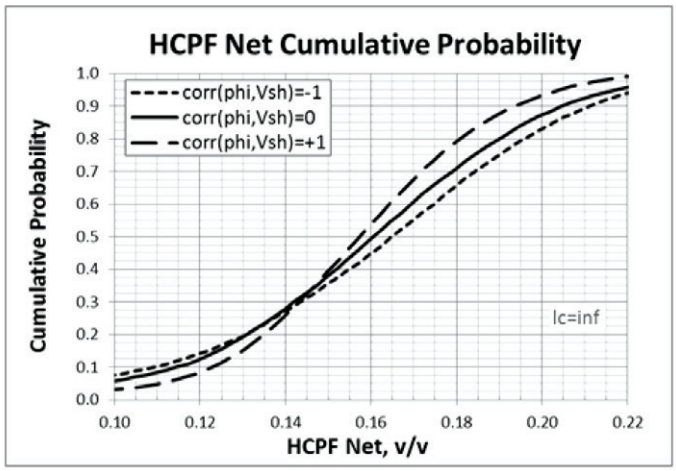


Fig. 15—*HCPF* evaluated using default for cases with perfectly correlated, uncorrelated, and anticorrelated V_{sh} and porosity errors.

EXAMPLE WITH A PETROPHYSICAL CUTOFF

The examples in the previous section did not use a cutoff; therefore, a N/G distribution was not referenced, and there was no reason to use conditional distribution in evaluating the summarized properties. The calculations for the correlated Archie parameters are now repeated with an additional variable representing the shale volume cutoff (V_{sh_c}) condition (Table 1). The cutoff condition is assigned the same correlation distance as the other variables. Cases with correlations between errors for the shale volume (V_{sh}) and V_{sh_c} of 0, +1, and -1 are considered. This example is an extension of the comparison in Fig. 7.

The N/G cumulative probabilities in Figs. 16a, 16c, and 16e are for correlations between errors for V_{sh} and V_{sh_c} of 0, -1, and +1, respectively. Figure 9.1 (b), Figures 16d and 16f show the corresponding P10, P50, and P90 N/G values. The spread between the P10 and P90 N/G is significantly reduced when the errors in V_{sh} and V_{sh_c} are positively correlated than when these errors are uncorrelated or negatively correlated. This is because the population of differences, $V_{sh} - V_{sh\_c}$, is more narrowly distributed and less likely to change sign (±) at any given depth along the well when the errors are positively-correlated compared to the uncorrelated and negatively-correlated cases. The discussion of the P50 N/G values shown in Fig. 7a applies and is not repeated here.

Histograms that represent the joint PDFs for N/G and net average are shown in Figs. 17a, 17c, and 17e for the case of uncorrelated errors between V_{sh} and V_{sh_c} and correlation distances of 3, 24, and m. The spike on Fig. 17e for l_c = ∞ corresponds to the highest-quality rock near the top of the reservoir. In cases where almost no other part of the reservoir passes the cutoff condition, this part enters the summary as a unit when correlation distances are large. This spike is much smaller for l_c = 24 m, and it is absent from the graph for l_c = 3 m. The comparison of the property distributions for the P50 N/G discussed in relation to Fig. 7 illustrates that there can be a substantial benefit of using joint distributions instead of treating the N/G and net average property values as independent statistical quantities. For the sake of comparison, Figs. 17b, 17d, and 17f show histograms corresponding to independently-evaluated results in each dimension that were multiplied to yield the 2D histogram shown. (Recall that the PDF for two independent variables is the product of their individual PDFs.) As expected from Fig. 7, the independent and joint histograms are remarkably similar when the correlation distance is small but are dramatically different when it is large. These differences were quantified in the section on "Petrophysical Cutoffs" to conclude that it is worthwhile to use the joint histograms. Results derived from the joint histogram properly reflect the fact that the net-average *HCPF* is higher for the lowest N/G values because the highest-quality part of the reservoir passes the cutoff condition when much of the rest does not.

Figures 18a, 18c, and 18e are the conditional cumulative probability distributions for the *HCPF* evaluated from joint distributions for the P10, P50, and P90 N/G, respectively. Results from treating the N/G and *HCPF* as statistically-independent quantities are shown in Figs. 18b, 18d, and 18f. Table 3 lists the P50 value for each distribution in Fig. 18 and the percentage difference between the "joint" and "independent" cases. The percentage differences increase with the correlation distance and decrease with the N/G value.

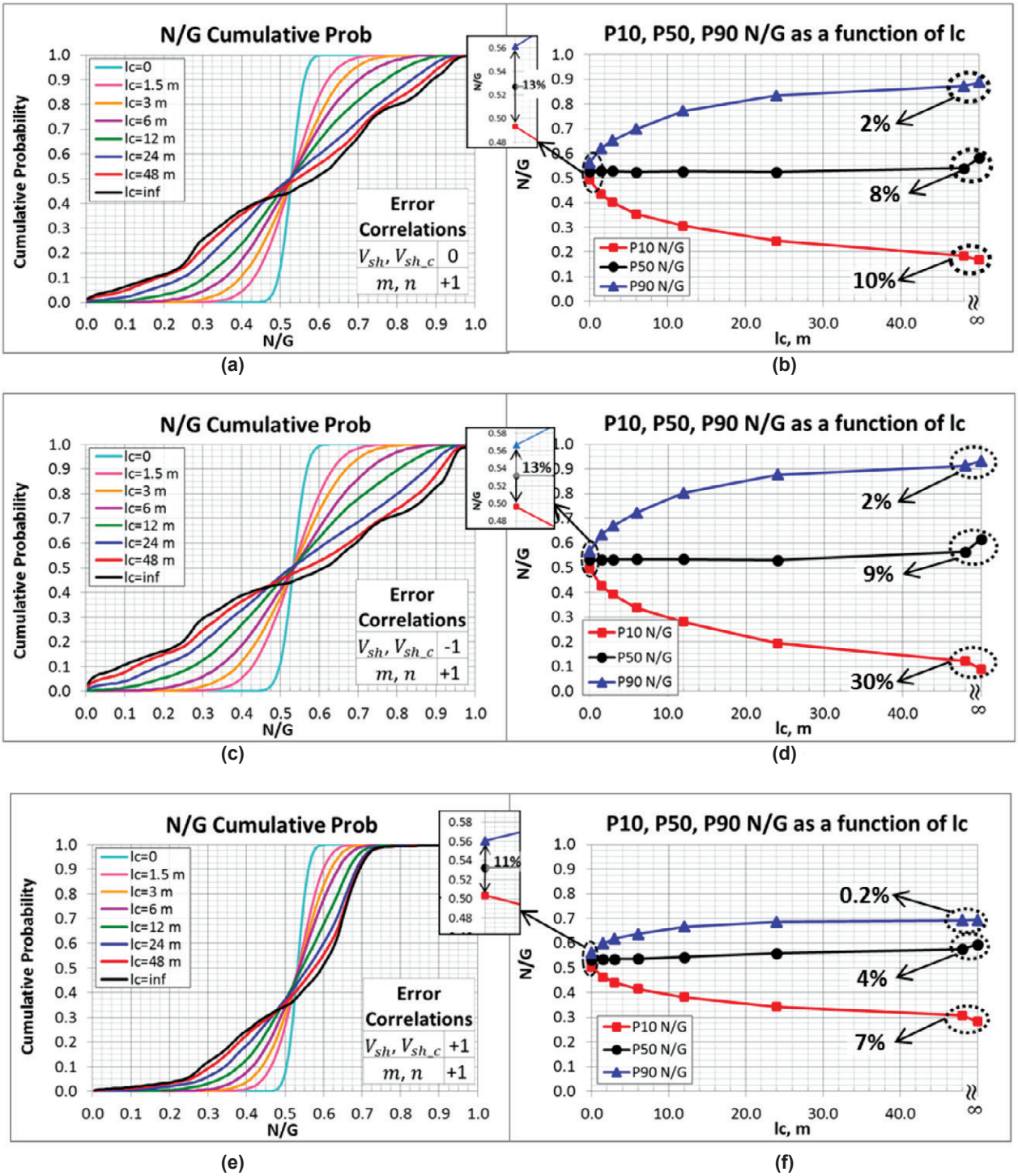


Fig. 16—Cumulative probability for N/G for the indicated error correlations and correlation distances are shown in (a), (c), and (e). The corresponding P10, P50, and P90 N/G values are plotted as a function of correlation distance in (b), (d), and (f).

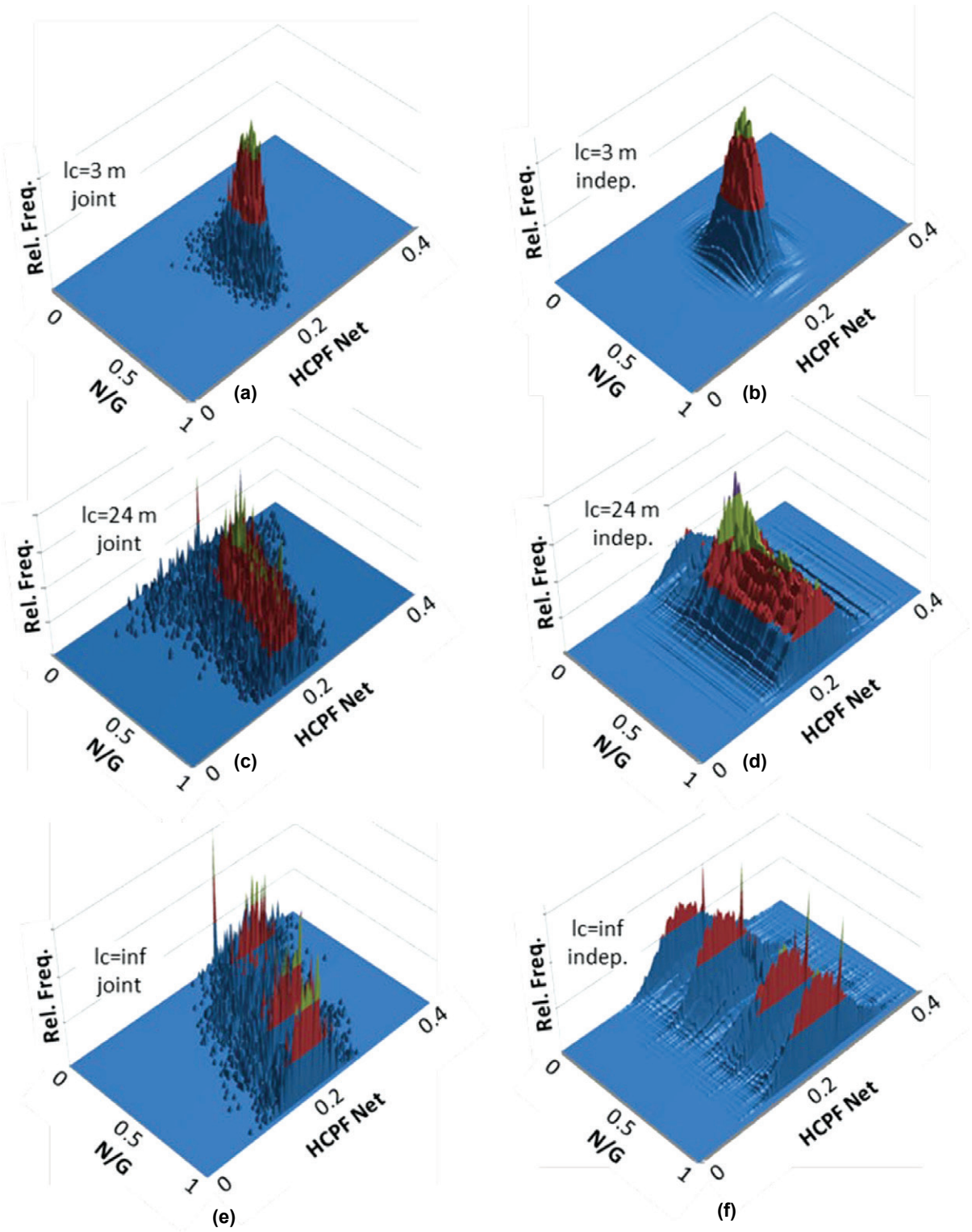


Fig. 17—2D histograms representing joint PDF for net-average *HCPF* and N/G for correlations distances of 3, 24, and m are shown in (a), (c), and (e). For comparison, the histograms on the right labeled "indep." are displayed in (b), (d), and (f). Errors between V_{sh} and V_{sh_c} are uncorrelated; so, these graphs correspond to Fig. 16a.

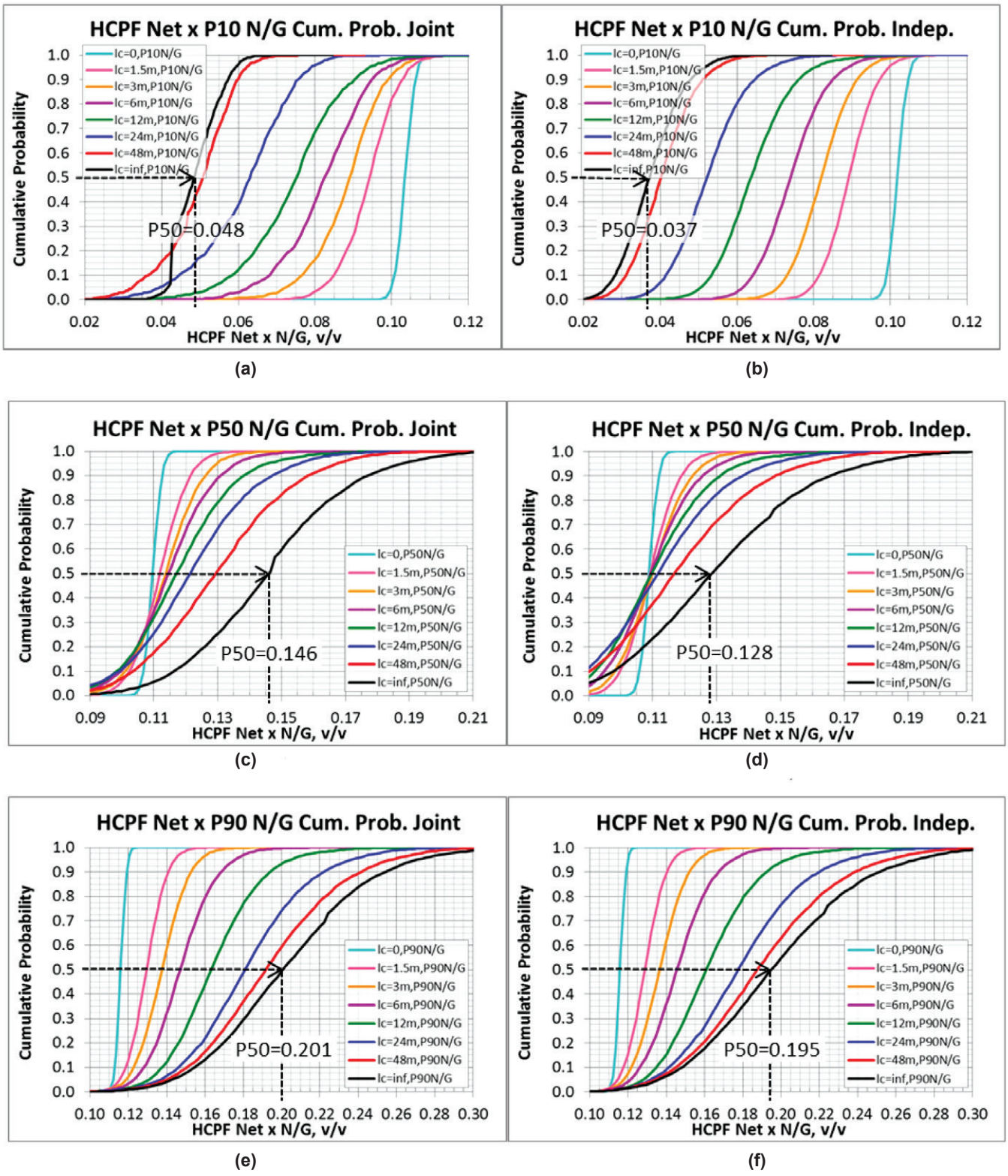


Fig. 18—Cumulative probability distributions for net average *HCPF* × N/G given the N/G-value indicated on each graph. The errors between V_{sh} and V_{sh_c} are uncorrelated. Results in (a), (c), and (e) were evaluated correctly using a joint distribution. The results in (b), (d), and (f) were evaluated assuming the *HCPF* and N/G are statistically independent quantities.

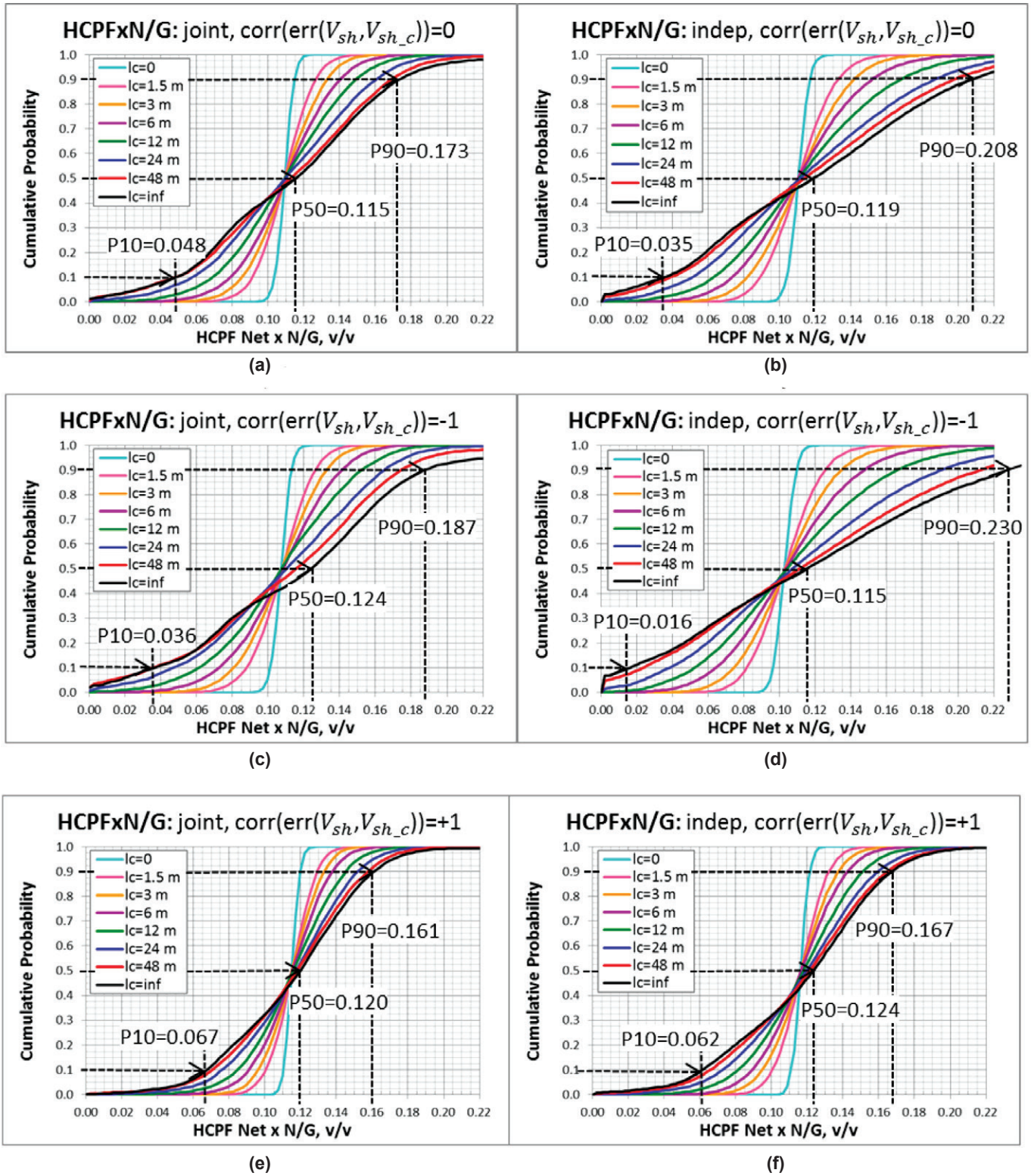


Fig. 19—Cumulative probability distributions for *HCPF* × N/G for uncorrelated errors between for V_{sh} and V_{sh_c} corresponding to the N/G in Figs. 16a. Results in (a), (c), and (e) were evaluated correctly using a joint distribution. The results in (b), (d), and (f) were evaluated assuming the *HCPF* and N/G are statistically independent quantities.

Table 3—Comparison of P50 *HCPF* × N/G as a Function of Correlation Distance for the P10, P50, and P90 N/G.

	P50 (*HCPF* × N/G) P10 N/G			P50 (*HCPF* × N/G) P50 N/G			P50 (*HCPF* × N/G) P90 N/G		
I_c (m)	Joint (v/v)	Independent (v/v)	Difference (%)	Joint (v/v)	Independent (v/v)	Difference (%)	Joint (v/v)	Independent (v/v)	Difference (%)
0	0.103	0.102	1.7	0.110	0.109	0.7	0.116	0.116	0.2
1.5	0.094	0.089	5.7	0.112	0.109	2.4	0.129	0.129	0.6
3	0.089	0.082	8.6	0.114	0.110	3.4	0.138	0.136	0.8
6	0.083	0.074	11.7	0.115	0.109	4.8	0.147	0.145	1.0
12	0.075	0.064	18.1	0.117	0.110	6.7	0.163	0.161	1.5
24	0.063	0.052	20.8	0.121	0.112	8.7	0.181	0.178	1.8
48	0.051	0.040	26.4	0.129	0.117	10.9	0.192	0.188	2.2
∞	0.048	0.037	30.6	0.146	0.128	13.6	0.201	0.195	3.0

Results from both joint and independent distributions are shown along with their difference expressed as a percentage of the 'Independent' value. This case is for uncorrelated errors between V_{sh} and V_{sh_c}.

Consistent with the N/G graphs in Fig. 16, the net-average *HCPF* distributions for the cases with the negative correlation between errors for V_{sh} and V_{sh_c} are wider with more variability in their P50 values than those shown in Fig. 18 and Table 3. The opposite is the case for the positive correlation between the errors for V_{sh} and V_{sh_c}.

The results in Fig. 18 and Table 3 are presented to provide insight. Results of this type are useful for field development planning, reservoir modeling, and to generally understand how the reservoir quality varies as a function of N/G. For the purpose of reserves estimation, distributions for *HCPF* × N/G are required. There is no need to introduce an equivalent sample thickness as suggested by others[14], but if this is done, a self-consistent implementation requires the use of the correct conditional property distributions. Instead, the distributions for *HCPF* × N/G are evaluated directly (Fig. 19). The data displayed in graphs in Figs. 19 a, 19c, and 19e are based on the joint distribution for *HCPF* and N/G. For comparison, Figs. 19b, 19d, and 19f show equivalent results evaluated on the assumption that *HCPF* and N/G are independent statistical quantities. The differences are substantial, especially under the default assumptions and for the P10 which is relevant for proven reserves. The P10, 50, and 90 values for the $I_c = \infty$ case are shown on each graph. This is quantified for the other correlation distances in Table 4 for the case of uncorrelated errors between for V_{sh} and V_{sh_c}. As evident from Fig, 19, these differences are larger when the correlation coefficient is negative and smaller when it is positive.

DISCUSSION AND CONCLUSIONS

In the examples without a cutoff condition, the median (P50) values for the petrophysical summaries often depended weakly on both spatial correlation and cross-correlations between variables. In one example, differences of about 6.5% in the P50 net average hydrocarbon pore fraction (*HCPF*) were observed. In addition to providing an assurance of the P50 value given the types of errors considered here, the benefit of accounting for both types of correlation in these examples is to obtain more accurate values for the spread of the distributions, such as P10 and P90. This spread depended strongly on the spatial correlation, and for large spatial correlations, it also depended substantially on the cross-correlation that was included in the calculations. The effect of this cross-correlation diminished as the correlation distance decreased. Use of the default assumptions for evaluating these petrophysical summaries resulted in an underestimate of P10 (proved) reserves and an overestimate of P90 (proved + probable + possible) reserves in the relatively simple case considered here, a clastic reservoir.

For the same set of logs and parameters, the effect of applying a shale volume cutoff condition was investigated. A net/gross (N/G) ratio was introduced and used to scale volumes such as porosity, shale volume (V_{sh}), hydrocarbon pore function (*HCPF*), etc. Care was taken to treat the N/G and each associated petrophysical property distribution as a pair of jointly-distributed random variables. Accordingly, the N/G was treated as an independent variable and each property distribution as a conditional variable for a given N/G value. For comparative purposes, a set of approximate results was also evaluated assuming statistically independent N/G and property distributions. Also, two sets of results were analyzed. In the first, the petrophysical property distributions were treated as a conditional variable for a given N/G. This is useful for understanding how the reservoir properties depend on N/G. In the second set of results with the cutoff condition, distributions for N/G × *HCPF* were evaluated directly to give a more direct indication of their impact on volumetric

Table 4—Comparison of P10 (*HCPF* × N/G), P50 (*HCPF* × N/G), and P90 (*HCPF* × N/G) as a Function Of Correlation Distance.

	P10 (*HCPF* × N/G)			P50 (*HCPF* × N/G)			P90 (*HCPF* × N/G)		
l_c (m)	Joint (v/v)	Independent (v/v)	Difference (%)	Joint (v/v)	Independent (v/v)	Difference (%)	Joint (v/v)	Independent (v/v)	Difference (%)
0	0.104	0.104	-0.2	0.109	0.111	-1.2	0.115	0.117	-2.1
1.5	0.091	0.089	2.3	0.109	0.111	-1.3	0.126	0.133	-4.9
3	0.085	0.082	4.2	0.110	0.111	-1.3	0.133	0.142	-6.1
6	0.079	0.073	7.5	0.110	0.110	-0.6	0.140	0.152	-7.7
12	0.069	0.063	9.1	0.109	0.111	-1.5	0.149	0.168	-11.1
24	0.058	0.051	13.1	0.109	0.112	-1.9	0.160	0.187	-14.3
48	0.048	0.039	23.8	0.112	0.114	-1.3	0.169	0.198	-14.6
∞	0.048	0.035	37.5	0.115	0.119	-3.0	0.173	0.208	-16.7

Results from both joint and independent distributions are shown along with their difference expressed as a percentage of the 'Independent' value. This case is for uncorrelated errors between V_{sh} and V_{sh_c}.

calculations.

Treating the petrophysical properties as a conditional distribution for a given N/G caused a nearly 15% underestimate of the median *HCPF* for large correlation distances. For the P10 N/G, the corresponding underestimate was about 30%. The P50 property values from this approximation agreed with the jointly-evaluated results for small correlation distances and only slightly underestimated the properties for the P90 N/G. For large correlation distances, treating the N/G and property values independently also caused P50 results to be much less sensitive to cross-correlations than they should be. Both methods gave 10 to 30% higher median *HCPFs* ompared to a case where uncertainty was neglected.

Treating the N/G and property values independently lead to larger errors in the petrophysical property distributions because the parts of the reservoir with the most favorable properties satisfied the cutoff condition more frequently than the more marginal parts of the reservoir. This is lost when the N/G and property value are treated independently. This effect was the most severe when the correlation distances are large in the above examples.

In the examples shown here, the P10 value (corresponding to proved reserves) increased when the dependency between N/G and *HCPF* was accounted for under the default assumptions.

ACKNOWLEDGEMENTS

The authors thank Equinor, Shell, and Gatecliff LLC for their interest in this work and permitting its publication. They are also grateful to Dr. Emma Stone for reviewing and commenting on the paper, particularly with respect to its statistical content.

NOMENCLATURE

CDF = cumulative distribution function
FVF = formation volume factor
GR = gamma-ray log value
GR_{sa} = gamma-ray log reading in a pure sand formation
GR_{sh} = gamma-ray log reading in a pure shale formation
GRV = gross rock volume
HCPF = hydrocarbon pore fraction
HCIIP = hydrocarbon initially in place
l_c = correlation distance
m = Archie cementation exponent
n = Archie saturation exponent
N/G = net/gross ratio
PDF = probability density function
$r_{ij}(0)$ = a cross-correlation between variables *i* and *j*
R = autocorrelation function
R_{sh} = shale resistivity
R_t = formation resistivity
R_w = water resistivity
S_w = water saturation
V_{sh} = shale volume
V_{sh_c} = shale volume cutoff
z_1, z_2 = two depths across which an autocorrelation applies

2γ = a variogram
ρ_b = bulk-density log value
ρ_f = fluid density
ρ_{ma} = matrix density
σ = standard-deviation of a statistical distribution
ϕ_e = effective porosity
ϕ_t = total porosity

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Rt-SIG: Publication of Technical Documents on Deep Azimuthal Resistivity LWD Services

During the biannual Resistivity Special Interest Group (Rt-SIG) meeting held at Southwestern Energy in May 2016, three speakers, Michael Rabinovich (BP), Jean-Michel Denichou (Schlumberger), and Gavin Lindsay (Baker Hughes), together gave a presentation and organized a panel discussion titled "Shall We Cooperate when Introducing New Technologies? Deep and Extradeep Azimuthal Resistivity Examples." The panel discussion focused on the challenges that operating companies had been facing in using and comparing different logging-while-drilling (LWD) deep resistivity services available on the market. The speakers proposed to bring all LWD deep-resistivity services into conformity with a single standard covering aspects, such as parameter definitions, benchmark modeling, and delivery visualizations. Later on, this proposal stirred lots of heated discussion in the resistivity community, which eventually led to an action item to form an industrial workgroup to discuss the related issues and find potential solutions.

Initiated in June 2016, and facilitated by the SPWLA Rt-SIG, the Standardization of LWD Deep Azimuthal Resistivity Services (SDAR) workgroup was formed. It is an industrial advisory committee, which is composed of technical experts and representatives from oil companies, oilfield service companies, and universities. The sole purpose of the SDAR workgroup is to promote deep azimuthal resistivity LWD services within the oil and gas industry and provide recommendations on standardization of these services from the technical perspective. To make the discussion fair and efficient, participation has been limited to one representative per organization. As of today, the participating organizations consist of the following (in alphabetic order): Aramco Services Company, Baker Hughes GE, BP, Chevron, ConocoPhillips, Equinor, ExxonMobil, Halliburton, Maxwell Dynamics, Q.E.D. Petrophysics LLC, Schlumberger, Shell, University of Houston, University of Texas – Austin, and Weatherford.

From June 2016 to October 2017, the workgroup had organized eight meetings and progress has been shared regularly at Rt-SIG biannual meetings. The workgroup discussed many technical details on the existing deep-resistivity services, including definitions of key parameters, benchmark models, forward modeling and inversions, uncertainties, final deliverables, presentation format, predrill studies, real-time operation requirements, etc.

Through the discussions, the workgroup understood that each service company has its own tool design and interpretation workflow. It is worthwhile to mention that even some basic terminologies have different definitions and meanings for different service companies, making it arduous to provide a practical deep-resistivity service standard to the industry. By the end of 2017, the workgroup had achieved the following

- Completed an existing LWD resistivity-tool survey (by November 2016) compiled by John Zhou (Maxwell Dynamics).
- Completed a survey on several key specification parameters of LWD deep-resistivity tools compiled by Jiefu Chen (University of Houston).
- Proposed benchmark models compiled by Hezhu Yin (ExxonMobil) and Ettore Mirto (Schlumberger). These benchmark models and other documents are available at the SPWLA Rt SIG website.

In April 2018, the workgroup reviewed the progress of the past two years and decided to prepare a comprehensive document to describe each deep-resistivity tool and its related service with a consistent outline. As suggested by Michael Rabinovich (BP) and Hanming Wang (Chevron), a detailed outline was provided to the four major service companies: Baker Hughes GE, Halliburton, Schlumberger, and Weatherford. The subject of the outline covers all aspects of deep azimuthal resistivity LWD services, including tool physics and configuration, key parameter definitions, major applications, real-time workflow, predrill studies, post-drill studies, and references. The detailed outline is listed in Appendix 1.

Representatives from these four service companies, Sergey Martakov, Tim Parker, Giorgio Nardi, and Ettore Mirto, have spent a great deal of time collecting the related information and preparing the documents for each tool. Table 1 lists the deep azimuthal resistivity tools included in this effort. Five technical experts from operators, Michael Rabinovich, Teruhiko Hagiwara, Hezhu Yin, Hanming Wang, and Frank Antonsen, were invited to review all the documents and provide feedback to the service companies to ensure the quality of the documents. Please note that reviewers' comments from Michael Rabinovich, Teruhiko Hagiwara, and Frank Antonsen are included in Appendixes 2 to 4..

Table 1—The Service Companies and the Deep Resistivity Tools Included in This Project

Company	Tool Name
Baker Hughes GE	AziTrak, VisiTrak
Halliburton	EarthStar
Schlumberger	GeoSphere HD
Weatherford	GuideWave

All the documents have been published on the SPWLA Rt SIG website by June 2019. The workgroup believes that these documents will certainly provide a good reference to the available deep-resistivity LWD services and, thus, help the industry to understand and promote these services.

It is worth noting that, even though all the documents are presented together, it is not meant to be a comparison of the services from these four companies. In fact, as mentioned above, readers should be aware that service companies have their own unique specification definitions. One should not just simply compare the values for a given parameter. It is highly advisable to always contact service companies for additional information and explanation.

Readers should be also aware that service companies are continually improving their technologies and developing new tools. They might change their tool design or interpretation workflow after these documents are published. Clearly, one should always contact service companies for the latest information.

We would like to take this opportunity to thank all the organizations and their representatives mentioned above for their support throughout the workgroup activities. Without them, the SDAR workgroup could not have been successful! Our sincere gratitude goes to Ettore Mirto, Sergey Martakov, Tim Parker, and Giorgio Nardi for preparing the technical documents. It required a tremendous effort to coordinate within their companies, drafting the documents, and getting publication approval from upper management and their legal departments. Last by not least, we would also like to thank our reviewers, Michael Rabinovich, Teruhiko Hagiwara, Hezhu Yin, Hanming Wang, and Frank Antonsen, for the large amount of time they spent reviewing the documents and providing valuable comments.

Sincerely,
Hui Xie
SDAR Workgroup Coordinator
Senior Modeling and Simulation Engineer
Schlumberger

Fei Le
Former SDAR Workgroup Coordinator
Manager EM Product Development
Baker Hughes, GE

Appendix 1

The following is the complete outline for each deep-resistivity service document. Thanks to Michael Rabinovich for providing the original topics. Hanming Wang, Teruhiko Hagiwara, and Hezhu Yin have also reviewed and contributed to the content.

1. Tool main applications
2. Tool physics (optional)
3. Tool configuration (if any)
4. Measurement point and sonde error
5. Depth of detection (DoD), depth of investigation (DoI), Picasso plots with proper explanations on how they are calculated.
6. Real-time data quality check
7. Standard customer channels for real-time and memory data
8. Real-time and post-well processing workflows (include all available options)
9. Summaries of all applicable processing/inversion algorithms including dataflow and uncertainty estimation, and selection criteria for individual processing.
10. Predrill studies: required input (including essential, good to have, and optional) and accepted formats, provided outputs, options available, additional tools for optimizing BHA, examples of predrill results (pre- and post-drill examples are preferably from the same case studies), etc.
11. Real-time operation/collaboration with clients—best practices, online real-time display sharing, etc.
12. Post-drill studies and integration: required input if any, provided outputs, options available, examples of post-drill results ((pre- and post-drill examples are preferably from the same case studies), etc.
13. List of appropriate references with tool details, processing algorithms and case studies (pre- and post-drill examples are preferably from the same case studies).

Appendix 2: Comments from Michael Rabinovich

This publication of Technical Documentation for Deep and Ultradeep Directional Resistivity tools by all four major service companies represents a significant milestone in the activity of the SPWLA SDAR SIG. Organized more than two years ago, we, as a group, came a long way from just having unstructured never-ending technical discussions and disagreeing on almost everything to this stage where we are publishing five very useful documents that will hopefully simplify and increase the use of this very promising technology. This achievement is also an example of productive technical collaboration between service and operating companies and we hope to build on this experience.

Although the group had proposed a standard outline, all reports are quite different in size, depth of coverage of specific topics and sometimes even in terminology. Based on our multiple in-depth discussions with the authors of these documents, I would like to share a few comments/observations that may explain some of the differences in these documents and answer some of the potential questions readers may have while reading these documents:

- There is no doubt that with this technology, different service companies are at different stages of its

development and commercialization.

- All the service companies want to protect their intellectual property and that is one of the reasons why some of the topics may not be fully disclosed.
- For this technology there are no industry standards for the very important tool characteristics, such as depth of investigation (DoI), depth of detection (DoD), measurement resolution and inversion uncertainties. As a result, all providers use their internal definitions and algorithms to calculate these characteristics. Consequently, it does not make any sense to make direct comparisons of these values from different vendors. For example, in the reports the included DoD Picasso plots or DoD tables are all calculated using different assumptions, different numbers of measurements and different thresholds.
- While even the presented DoD values are often too optimistic, in my opinion, they are still very useful to see how a particular tool may perform in different environments. Obviously, the most accurate DoD estimates are coming from predrill studies conducted by the vendors.
- Be aware that all vendors have different (and usually more than one) inversion algorithms and the fact that they use different presentation formats and different techniques to show inversion uncertainties does not help in understanding the technology.
- This technology is still undergoing development. New tools with improved hardware and electronics and new inversion algorithms come to market quite regularly. It means that parts of these documents may quickly become outdated. We hope that the developers will be updating these documents in a timely manner, however, we recommend users always check with service company domain champions before making any important decisions based on the published documents.

Appendix 3: Comments from Teruhiko Hagiwara

These documents should be helpful to understand the technology and to use the technology effectively. The documents are to be organized in the same format, covering the same contents. This should make it helpful to study different tools and services side by side. However, be aware that some tool specifications, such as depth of detection (DoD), do not always have the same definitions, and they are evaluated differently at different conditions if the same definitions are used.

Although we wanted these documents to be consistent with the SDAR guidelines for the format and content, each document follows the guidelines differently. Depth of detection (DoD) appears frequently but is not even defined in one document. The details of processing are not sufficiently explained. But overall, I appreciate that all four service providers have accomplished documenting these technology guidebooks. I hope these documents will help us to understand the technology better and to use it more effectively.

Appendix 4: Comments from Frank Antonsen

Here are some comments on the future potential improvement of the service:

- **Quality Control.** The ultradeep directional resistivity inversions have been extremely useful for operators around the world, and we are updating our models based on inversion results. However, so far I have not seen any service company provide quantification of transmitter and receiver performance during drilling. If the transmitter and/or one or more receivers are changing performance (for instance drift) while drilling, this will of course be translated into a change in reservoir structure or quality, if it is not detected, due to change in inversion results. I hope that we will see an improvement of quality control of while-drilling UDAR tools in the future. The operators are of course paying for a perfect tool and our interpretation is based on that. I would like to see efforts to quantify potential effects on inversions from known changes in transmitter or receiver performance during drilling. This is extremely important, but I also recognize that this is sensitive information.
- **Operator Access to Forward Modeling and Inversion Algorithms.** The current workflows for using UDAR are suboptimal. They are suboptimal because the service companies do not capture all relevant geologic knowledge from the operators, and the operators do not always know in detail what the service company needs to do the best possible job. Thus, we have landed on a workflow that works okay, but it results in misinterpretation from time to time because of lack of knowledge either on the operator side and/or service company side. In the future, I think operators will have to step up on the modeling side to provide a set of more realistic geomodel scenarios (not just seismic surfaces and offset wells) around the well, and potentially do the forward modeling and inversion themselves on the scenarios to get more familiar with what the inversion algorithm can and cannot resolve; and from that experience identify geosteering decision points. (My experience, today, is that discussions between

an operating company and service company is spending more than 50% of the time discussing basic tool functionality and tool responses.) This will increase the likelihood of doing a better real-time job and will actually improve discussions with the service company as well, both before, during, and after drilling. In addition, the operators need access to inversion algorithms to potentially reprocess old data with new inversion algorithms. What I am describing here will be even more critical going full 3D in the future.

- **What Could we Expect With Wired Pipe?** This is a question I often get asked in Equinor. Drilling is pushing for the use of wired pipe in Equinor, but it is chasing us as well working with geosteering to potentially improve the business case for wired pipe. Do we see an upside for UDAR-technology with increased use of wired pipe in the future? This is just an open question from my side, but it could be an interesting starting point for discussing future possibilities and improvements in UDAR answer products.

Quantitative Mud-Gas Extraction and Analysis

Baker Hughes, a GE company, has introduced the TRU-Vision™ advanced quantitative gas extraction and analysis service, which quantifies over 25 gases, including light hydrocarbons from C_1–C_8 and key inorganic gasses, for the most accurate reservoir characterization available at the wellsite.

The TRU-Vision service meets all certifications required to operate in the most stringent regulatory environments. To ensure proper execution and safety standards, multiple automated and redundant shutoffs are implemented—monitored by certified-competent and experienced personnel.

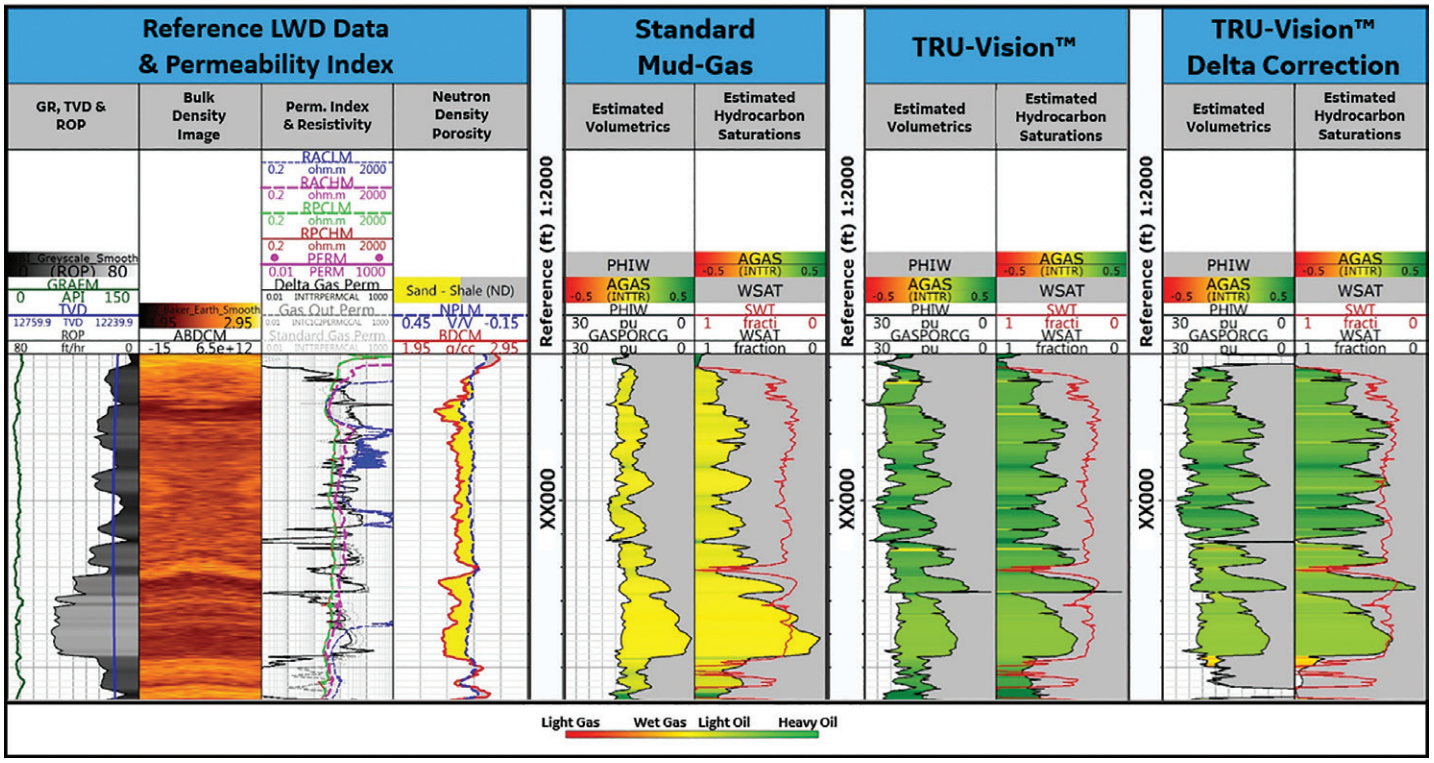
The TRU-Vision service leverages an optimized gas chromatography system to deliver quantitative fluid analysis in just 45 seconds—without compromising accuracy, precision, or the number of individual compounds separated in the analysis. This improved data density ensures faster operational awareness and more granular reservoir insights, such as:

- Natural fracture identification
- Seal/trap capacity
- Maturity, including bio or thermal degradation
- Fluid contacts
- Fluid characterization
- Drillbit metamorphism.

The TRU-Vision service includes a mud heater to maintain constant thermodynamic conditions at surface, so the quantitative gas readings remain true to actual readings at downhole conditions. Advanced mud-gas analysis is a cost-effective and low-risk solution to fill formation evaluation gaps from conventional downhole fluid-sampling programs, as well as wireline and LWD datasets.

Multiple well construction disciplines, including drilling, completions, and reservoir engineering, rely on these continuous and "early" mud-gas analysis data to update their existing models. This information drives well-construction efficiency, as well as improved completion, reservoir, and stimulation decisions.

www.bhge.com/upstream/drilling/drilling-services/surface-logging-services



Hydrocarbon saturations and volumetrics derived from TRU-Vision™ compared to standard mud-gas data and the resistivity-based petrophysical evaluation of the reservoir.

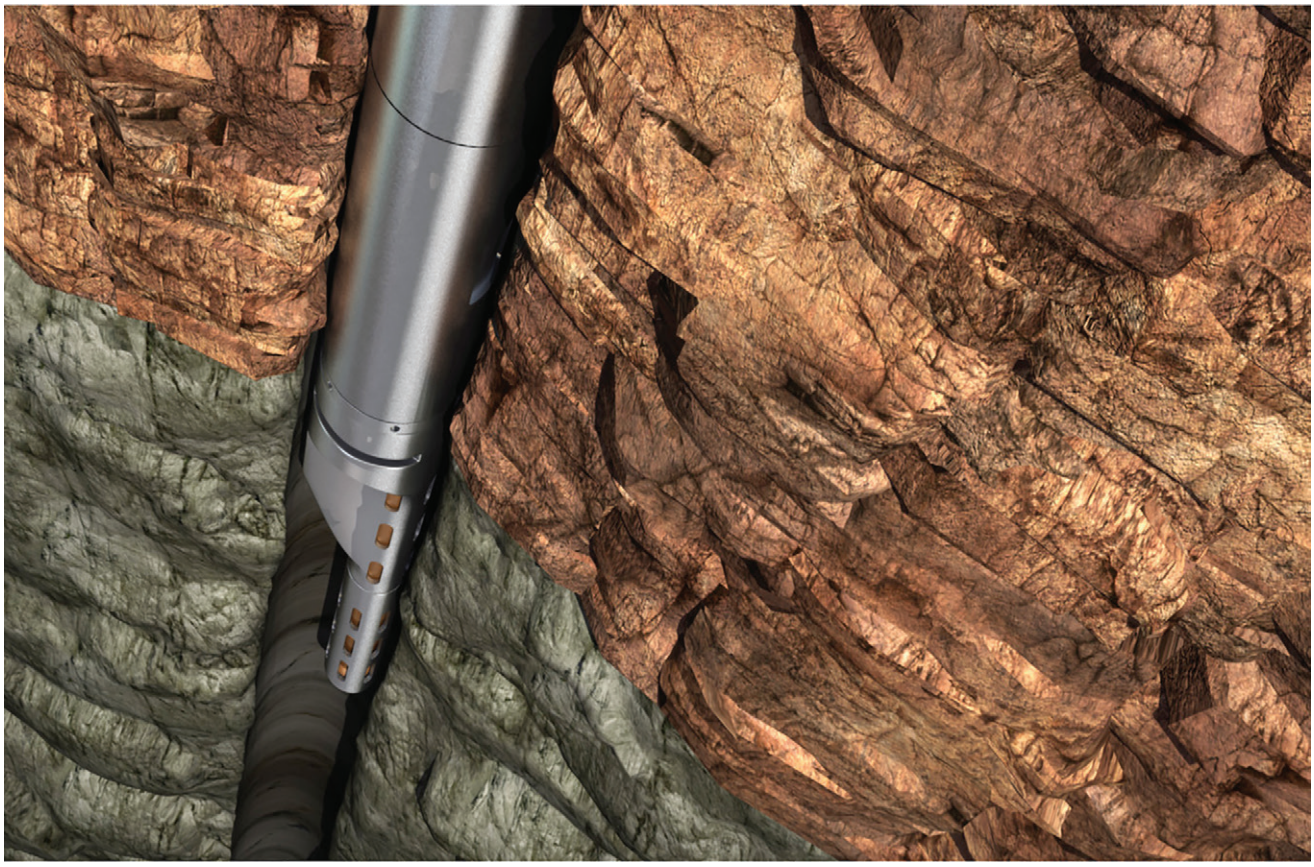
CoreVault System—World's First Rotary Coring Tool That is all About the Fluids

The Halliburton CoreVault® RFP (rocks-fluid-pressure) system is a next-generation reservoir evaluation technology targeting new exploration, mature, and unconventional fields. It integrates rock coring with fluid sampling and measurement of pressure and temperature downhole, while preventing fluids from escaping during the acquisition of high-quality, rotary sidewall cores. This unique solution provides an analysis of the complete reservoir. Operators can obtain and recover reservoir fluids and pressure-temperature measurements within rock samples to the surface, allowing for the volume measurement of hydrocarbons-in-place and safer, more reliable production forecasting.

In a recent case study, an operator in an unconventional play wanted an improved understanding of the subsurface reservoir to characterize thermal maturity near a boundary of its field. Changing source-rock maturity, especially as it relates to pore pressure, is a strong driver in field planning. Halliburton was selected to analyze the reservoir and provide a better understanding of the field's geologic trend, as well as offer timely solutions and recommendations. The CoreVault RFP system, integrated with additional petrophysical measurements, including the Halliburton Xaminer® MR (XMR™) service, acquired samples swiftly and economically.

By combining the CoreVault RFP and XMR data results with regional and specific subsurface information, Halliburton was able to transfer to the client a conclusive analysis of the reservoir characteristics, a better understanding of its economic value, and the risk associated with its reservoir. Wellsite surface analysis of the CoreVault RFP samples and XMR data revealed very little pressure, indicating that this asset would be unfavorable for production. The petrophysical analysis and core samples retrieved by Halliburton provided guidance for informed decision making on the future of this unconventional asset.

For more information and case studies, visit: Halliburton/CoreVault



The industry-first CoreVault® RFP system combines downhole fluid sampling, coring, and pressure-temperature measurements for more-accurate production forecasting.

New LWD Technology Provides Continuous Look-Ahead Capability Through Advanced Formation Boundary Detection

When it comes to the exploration and appraisal of vertical wells, operators have always faced many challenges related to drilling risks and geological uncertainties. Today, the industry takes a reactive approach to addressing such challenges, including effective positioning of the casing shoe above a problematic zone or a reservoir, optimizing the coring location, geostopping before potential high-pressure or depleted zones ahead of the bit and avoiding potential kicks, mud losses or stuck pipe.

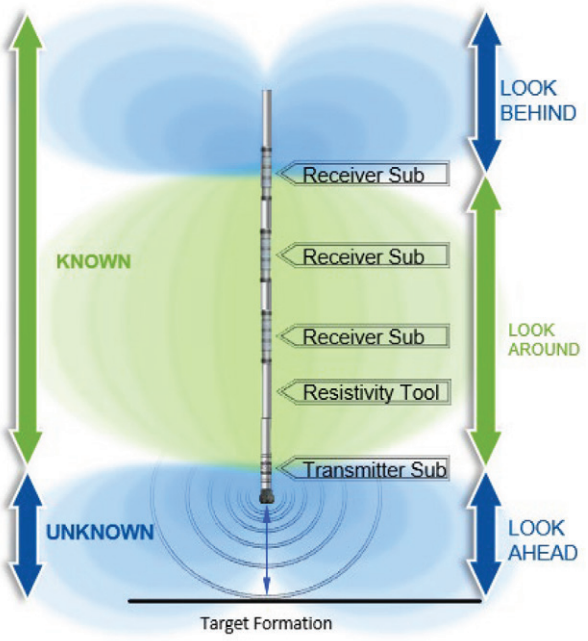
With the recent introduction of the IriSphere look-ahead-while-drilling service from Schlumberger, real-time detection of resistivity features up to tens of meters ahead of the bit enables proactive drilling and geological risk reduction related to the exploration challenges mentioned above.

The IriSphere service provides formation boundaries and the resistivity profile ahead of the bit continuously while drilling, based on electromagnetic (EM) deep directional resistivity measurements, to deliver an accurate representation of what is ahead of the current drilling depth. The service is available from 5.625-in. hole section to 16-in. hole section.

The technology consists of a set of deep directional transmitter subs and multiple receiver subs providing flexible multispacing and multifrequency 3D measurements in real time. Four basic types of measurements are used, each with a different spatial sensitivity, to invert for a 1D formation (layer-cake) model. With more than 100 measurements generated in real time, the automated real-time inversion inverts for the entire volume of investigation defined by the largest transmitter-receiver spacing. These automated real-time inversions generate high-resolution 1D formation resistivity profiles ahead of the bit, enabling proactive drilling decisions rather than reacting to measurements at or behind the bit.

Look-ahead sensitivity depends on the transmitter to longest receiver spacing, the conductivity volume and the resistivity contrast ratio. This can be simulated during the prejob modeling stage to estimate the service capability under the expected drilling conditions.

For further information, visit https://www.slb.com/irisphere



EM look-ahead main measurement with look-behind, look-around and look-ahead capability. The look-ahead sensitivity is in the lower blue lobe below the transmitter and bit. Inversions can be run without any assumption on the formation being inverted or with the assumption about a known formation (formation already crossed and characterized by the tool and LWD resistivity measurements). Image courtesy of Schlumberger.

SPWLA Young Professionals Newsletter

the bridge

Perspectives of Young Professionals on New Trends in O&G Upstream Engineering and Technology

Yifu Han

Yifu Han is a scientific computing engineer at Schlumberger Beijing Geoscience Center, China. He has focused on the development of novel formation testing and deep transient testing techniques, and he also works with software developers to add new features to Schlumberger formation testing software InSitu Pro. He obtained a MS from the College of Earth & Energy, University of Oklahoma. He worked as a graduate research assistant at University of Texas at Austin, and R&D intern at Saudi Aramco Beijing Research Center, before joining Schlumberger Beijing Geoscience Center in 2018. He has coauthored seven peer-reviewed journal publications on data inversion, electromagnetic data interpretation, and multiscale rock physics, and also one patent application.

Shiv Ojha

Shiv Prakash Ojha is an Associate Engineer at the Reservoir Studies Division of DeGolyer and MacNaughton. His work focusses on production performance analysis, reservoir simulation, and flow simulation in production networks. He completed his bachelor's degree in Petroleum Engineering from Indian Institute of Technology (Indian School of Mines), Dhanbad, India, in 2012. He graduated with a master's degree in Petroleum Engineering from the University of Oklahoma in 2017. During his graduate research, he worked on the interpretation of petrophysical measurements using percolation theory for estimation of relative permeability in shale reservoirs. Additionally, he worked on applications of fast-marching method for pressure transient analysis in naturally fractured heterogeneous reservoirs. His work on these subjects was published in around 10 journal and conference papers. Prior to this, he worked as a Reservoir Engineer at Cairn India Ltd. In this position, he worked on the improvement and application of modeling workflows for jet pumps and ESPs for production optimization on onshore fields.

Edited by Dr. Sid Misra

What are some new trends and technologies that you have encountered or you have seen other young professionals encountering in the day to day work?

Digital transformation is a common goal for both operators and service companies. New trends in automation are vital for the envisioned digital transformation in the O&G industry. Automation will help field engineers/operators to remotely and safely complete their jobs on time with high productivity. Real-time automated interpretation will provide domain champions and clients with fast and accurate information about the reservoir and production systems. Automation requires high-quality data acquisition, fast and reliable data transmission, real-time data interpretation, and robust data quality control, which is contingent on improvements in both hardware and software components.

The application of data analytics and data-science techniques for automation and for increasing the efficiency of an O&G professional is an emerging trend in the O&G industry. For example, the work of a reservoir engineer is dominated by assimilation of data produced from different sources and interpretation of all available data for arriving at the best estimates of hydrocarbon reserves and and recovery. A

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reservoir engineer should be adept at working with production and reservoir surveillance data along with an integrated analysis of geophysical, petrophysical and geological inputs for reservoir simulation, and post-processing of simulation results.

Data-driven methods are crucial for precision engineering of the subsurface for improved oil and gas recovery. Data-driven modeling is now widely used in many areas of the O&G industry, such as preventive maintenance and drilling/production optimization. Data-driven innovations help the O&G industry to process unstructured data and metadata containing valuable information, which tends to be ignored when using traditional methods. For example, when drilling a well, machine-learning models can help to optimize the well plan and operational procedures based on measurements and responses of complex subsurface processes. Data-driven models can learn from one drilling operation and then provide better predictions and recommendations when drilling the next well. Another example involves formation testing, wherein machine-learning methods can be applied in monitoring the fluid-sampling procedure and pretest automation.

Another trend has been the transformation of several desktop-based software tools into cloud-based services. On the cloud, the software tools are accessed as web-based applications available through any device, such as personal computers, tablets, or phones. Such web-based applications provide better services because the software offerings can be tuned based on a dynamic understanding of the user interactions with the software modules and quick assessment of user experience. A new breed of professionals at the intersection of scientific computing, software development, and data security is needed to ensure a robust performance of cloud-based services because many users from various geographic locations simultaneously run these cloud-based resources on huge proprietary datasets on various device configurations. O&G software development teams have also started emphasizing UX (user experience) because the users are now exposed to various seamless UX designs in their personal lives.

Why are the new technologies and techniques better than the old ones? Where do you see the field evolving?

Application of data-analysis techniques leads to significant increase in the efficiency of an O&G professional. Efficient data management leads to a reduction in downtime associated with each data-retrieval operation. An automated workflow also assists in eliminating manual errors and human bias. The greatest advantage is evident when these data-analysis/management techniques are applied on huge datasets consisting of thousands of wells or on high-resolution measurements acquired at a high sampling rate from multiple sensors. These techniques allow a single engineer to review and analyze variety of data from thousands of different sources. A data-driven fast-paced analysis increases the efficiency of each and every task performed by the O&G professional.

For a long time, the innovation in O&G industry was driven by hardware, and software just followed the hardware. For example, when a new O&G tool/equipment was being developed by the physics and engineering teams, the role of software development team and data consulting teams was to develop software/techniques that support the implementation and interpretation of the hardware being designed. But the digital transformation needs the software development and data consulting teams to play a more important role in leading the innovations in tool development.

What needs to be done to master these new technologies and techniques?

For an individual O&G professional, expertise in data-analysis and cloud-based services/computing is an essential item in the toolkit to solve engineering, commercial, and operational tasks. If you look at recent O&G technical job postings, there has been an emphasis on required skills in programming, data management, and data analytics, which is an indication of changes to come in the future. Continuous self-motivated training is mandatory to master these new technologies. Basic programming skills or familiarity with a commercial machine-learning toolbox is necessary for professionals wanting to apply these techniques. There are many easily accessible online resources (almost free of cost) to learn about these new trends and to learn how to implement them in daily tasks.

How is the O&G community helping or adopting these new trends? What are some challenges and limitations of these new technology techniques?

The petroleum engineering community has been quick to respond to advent of data analytics and cloud services. Data scientists/analysts have been incorporated into multidisciplinary teams and are now key drivers for successful implementations of data-analysis workflows. Data analytics/science has now become a key area of research in the upstream O&G domain. This is evident from the large number of publications in this area and also the attention given to these topics in conferences and

symposiums. Also, several companies have brought their historical data from fields into the public domain, so that new innovations and improvements in the engineering/characterization can be accomplished through the publicly available data. The O&G community is adopting many technologies in automation process to reduce human intervention for safety and financial gains.

Data size in the O&G industry is much smaller than data size in internet or purely digital companies, such as Amazon, Netflix and Facebook. Consequently, machine-learning techniques combined with physical models do a better job in many O&G scenarios, as compared to pure machine-learning models or pure physical models. Data accessibility or availability is one of the biggest challenges in machine-learning applications for the O&G industry. The data security is also a big concern for the web-applications deployed on the Cloud. It is important to temper our expectations regarding the outcome of these new trends. Even the most advanced data-analysis methods are not likely to yield meaningful results if the measured data are inaccurate. Prudent engineering judgment will be required to discard spurious data and unreliable data-driven models. Additionally, there have been concerns about the repeatability of these methods when applied to different fields/assets. Quality and characteristics of the data is an important factor for the success of any technique in data sciences. Applications of the best techniques to variety of datasets over time will help in selection of optimum workflows for future analyses and robust implementations.

An interview with Don Westacott, Chief Advisor, Global Unconventional Reservoirs for Halliburton

Don Westacott

Don Westacott is the Chief Advisor, Global Unconventional Reservoirs for Halliburton. Don has pursued a lifelong interest in science and engineering beginning as a youth in western Canada. Don continued this interest and graduated from the University of Alberta, receiving a Bachelor Science in Electrical Engineering. During the last 40 years, he has worked in the E&P industry in Canada, the United States, Europe, the Middle East, and the Far East. Don's unconventional reservoir analysis work began in the early 1980s when he worked for Canadian Hunter Exploration. Don worked for the legendary oil and gas finder John Allen Masters and, with his mentoring, developed the fundamental skills of oil and gas exploration that he would apply through his continued career. Don developed reservoir characterization expertise while working for Apache Corporation, Carigali-Hess Malaysia, ResTech Houston, and Newfield Exploration. His technical area of interest led to publications of nuclear magnetic resonance applied to reservoir characterization. Don Westacott strongly considers training and technology transfer as an important part of his role within the E&P industry. Recently, Don accepted a role as guest lecturer at the Colorado School of Mines providing instruction to a new generation of petroleum engineering students. Don was honored this year to be the Distinguished Speaker at the Harvard University Energy Panel Arab Conference. Don and his wife Marilyn enjoy the success of their sons Matthew and Andrew.

How did you start your career in Petrophysics and Formation Evaluation?

As often the case, our professional careers are composed both of careful planning and the occurrence of random chance. Upon graduation from the University of Alberta my goal was to enter a career in the emerging satellite communications industry. I recognized a company logo at an on-campus career fair, conducted an interview and was essentially hired on the spot. Surprisingly, I was actually hired as wireline field engineer in the company's oilfield service division. After more than 40 years in the E&P industry I have no regrets, study of the subsurface, geology, reservoir engineering, petrophysics has been and continues to be both challenging and rewarding. I have discovered that looking downward into the earth is as fascinating as thinking 40 years ago of looking up into space.

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?

If I may, I would prefer to answer your question not with my achievements/accomplishments but rather and more importantly what I have learned. I have learned that our industry plays an important role. We are all in the energy business that powers the economic prosperity of the companies we work for and the nations we serve. We provide and generate the energy that lifts people and nations to growth. This is important and serious work that binds our industry together to form a common objective. I have learned we all share a common goal of producing energy safely, producing energy reliability and producing energy economically.

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

Challenges and opportunities are ubiquitous within the E&P industry. The challenge most often presented is to adapt to the constantly changing and increased rate of change of our industry.

How do you convey the importance of petrophysics/formation evaluation to your colleagues from other disciplines? Please share with us an interesting case or application of petrophysics/formation evaluation

Formation evaluation maybe considered to answer a single important question "So What?" Often, we be become focused on the technology, algorithms, and the science of the measurements; all of which are important. However, I would suggest it is important to pause during our work and consider the economic and strategic value of the technical services we are providing. The value of our work may be discovered asking ourselves and presenting/demonstrating to our colleagues how our technical results positively impact the economic outcomes and risk management process within our industry.

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

This is an important question and let me answer this is a slightly different format. Motivation is a product of the environment that an individual is exposed to. Motivation, like courage and leadership, comes from within an individual. These are difficult attributes to teach, I believe one simply has them or not. The role of people and organizations is to develop a framework and environment so that these skills may be fully developed and expressed. Organizations like the SPWLA provide valuable and recognized support to encourage young professionals to undertake a rewarding career in petrophysics. Our combined goal is to present a factual and opportunity-based career path for individuals interested in pursuing a career in petrophysics

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

I like to break down formation evaluation workflows into a seven-step method:

1. Balance the need to obtain more, better or new information, and know when to stop; do not overanalyze.
2. Seek information from different sources and perspectives through multiple collection methods.
3. Recognize trends or associations of data and acts on them.
4. Relate information from different sources to draw logical conclusions.
5. Identify possible cause-and-effect information.
6. Use judgment and common sense in getting down to the root cause.
7. Review information / data to stay informed of new developments and strategies.

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

The changes within the E&P industry have been profound and mirror changes within our society. Technology advancement, principally due to the computer revolution and access to information principally associated with the world wide web/internet, has changed the landscape of or business.

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

I had the great privilege to work early in my career with a great scientist and mentor at Canadian Hunter Exploration. In youth, we sometimes consider we now everything, with age we realize we really know very little. In these past Dr. Richard Wyman often reminded me “to keep an open mind to new ideas,” advice that I have honored throughout my career. I would like to share the following workflows to serve as a framework for formation evaluation.

- Gather information from a wide variety of sources when making important decisions. Thoroughly examine, weigh and use all relevant information.
- Double check data and assumptions related to important decisions.
- Talk with others in the organization to find out how they approached difficult data analysis projects.
- Be open to changing your decision if new information becomes available or if the situation changes.
- Analyze problems and opportunities from a broad organizational perspective rather than focusing solely on your area of responsibility or expertise.

How do you compare working for an operator and a service company? Would you point out the primary challenges on each side?

My answer, although it may be surprising to some, is that there is little difference working for an operator or a service company. Our work, and how we conduct it, is largely the responsibility of a single individual, Ourselves.

What was the project you worked on as an operator that you enjoyed the most? Why?

A project called Lochend. Thirty-five years ago at Canadian Hunter I presented a bold exploration play in the Devonian formation. As occurs with youth, I knew the play was a sure thing and would be an unquestionable success. The result, we drilled a dry hole. The legendary John Allen Masters, the founder of our company came to my office, closed the door and spoke these words. *"*Don, you have learned a valuable lesson, in this business you can't be right all the time.*"* John was my mentor, a leader, a great explorationist and inspiration to all that knew and worked with him. The project was a failure and it was my greatest personal success.

What was the project you worked on in a service company that you enjoyed the most? Why?

Recent events seem easier to recall than past victories. On December 25, 2018, standing on a wellsite in Prudhoe Bay, Alaska with a -50°F wind-chill factor brought a sense of accomplishment to me. Our team had just recovered the world's first fully preserved methane-gas-hydrate rotary pressure cores. This was a project I described as a "moon shot", never been done before and could not be fully simulated before the actual work was conducted. It all worked and was a memorable accomplishment in my career.

Would you please share with us how you came up with the pressurized core idea? And, how it evolved from the idea to the tool you have today?

Standing on the rig floor, I watched as we transferred the Eagle Ford core from our first discovery well. I observed gas bubbling from the conventional-core barrel and was overjoyed. Fifteen seconds later I was depressed, upset and even a bit angry. We were losing to the still night air of South Texas the very hydrocarbons that I was seeking to measure and quantify. On that rig floor that night, I vowed to change the status quo of formation evaluation, of coring services, I wanted to do something better.

In your view, what are the main challenges we are facing in the low-porosity/permeability (unconventional) projects?

I would suggest one major challenge is establishing what fluids are held within the rocks and what fluid will come out. Our industry is "all about the fluids", the hydrocarbons that represent the energy we produce and the value that we provide.

How many countries have you visited during your career and the one (outside North America) you liked the most?

I have stopped counting countries I have visited after the number exceeded my age. I think every country; every culture has something to offer. Travel offers insight and understanding of other nations and other people. Travel offers a perspective to what we enjoy in this nation but may not think about it routinely.

What would be your advice for early/midcareer petrophysicist?

Personal enjoyment, career development and value added to your employer is rooted within a continuous knowledge development procedure. Simply never stop learning new skills, expanding your knowledge base. Communications is most important skill and continue to practice the speaking and listening fundamentals.

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

The E&P industry is cyclic, this will not change. It is important to take control of your career, decide what you are going to do and then act. Like the famous country and western song, our industry is always a "gamble"; the words to the song may provide a form of guidance.

Wellsite photo on noon Christmas Day, 2018, Prudhoe Bay.

When drilling some exploration wells some 20 years ago in Western Desert, operating within the historic EL Alamein battlefield, this somewhat motley crew was assigned to clear unexploded ordinance left over from WWII. To be clear, I am standing third from the left with the somewhat improved footwear.

SPWLA Networking Happy Hour in May 2019

SPWLA members in the great Houston Metro area recently gathered at a known café to network in a relaxed atmosphere with great drinks and food. SPWLA members from all background and experience had the opportunity to interact each other with few SPWLA present and past officers joining them, including 2019–2020 SPWLA President, Dr. Jesus Salazar. As Fields' old quote says, "Why limit happy to an hour?" And that is literally what these folks did during this enjoyable event. Attendees had the opportunity to network, meet new colleagues, reconnect with known members and talk about the upcoming annual symposium in The Woodlands in June 2019. Several students from the SPWLA University of Houston Student chapter and two professors also joined us.

This social event was held in a popular place in Houston, Texas, with a location convenient to most people living in the area. These social events are rotated between different locations across H-Town so feel free to send us your recommendations if you are interested in joining us in a place near you where several members can attend as well.

SPWLA members and petrophysics enthusiasts gathered during May to share a good time during the most recent networking event at a known cafe, May 2019.

Not even the rain later that night could stop these SPWLA members and petrophysics enthusiasts from having a great time during the most recent SPWLA's Happy Hour, May 2019.

Canyon Creek Cafe's patio was the perfect spot to enjoy most recent SPWLA's Happy Hour, May 2019.

Some of the attendees from industry and academia (University of Houston) at the most recent SPWLA's Happy Hour at Houston's Canyon Creek Cafe, May 2019

SPWLA Networking Happy Hour in May 2019

SPWLA professional and student members having a great time in a known cafe in the great Houston area.

Jesus Salazar (right), 2019–2020 SPWLA President sharing his ideas for the society and receiving feedback from members.

Don't Miss Our Next Event!

Join us for our next event to kick off the 2019–2020 season. Our third 2019 SPWLA Networking Happy Hour will be held at Cedar Creek Café on August 22, 5:00–8:00 pm in a location accessible for anyone in the greater Houston area. The entire SPWLA community is invited, no need to RSVP, come at your own leisure, no payment required. Come and mingle with fellow petrophysics enthusiasts. Recent events have been well attended by geoscientists, engineers and managers!

Everybody is welcome!

When: 5–8 pm, Thursday August 22, 2019

Where: Cedar Creek Café Bar and Grill, 1034 W 20th St, Houston, Texas, 77008

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.

SPWLA 2019 Membership Benefits Survey Results

Tom Neville
SPWLA VP Publications,
2019-2020

Carlos Torres-Verdin
SPWLA VP Publications,
2018–2019

Background

This membership survey was suggested by former VP Publications, Carlos Torres-Verdín, and approved by the SPWLA Board with the intention of quantifying the relative value of SPWLA Publications, specifically *Petrophysics* and *SPWLA Today*, as part of the benefits of SPWLA membership.

Rationale

From 2017 to 2018 we greatly increased the number of papers and tutorials published in *Petrophysics*. Additionally, we introduced the *SPWLA Today* newsletter with the objective of capturing all nonpeer-reviewed material previously published in *Petrophysics* into a single informal publication. The motivation behind starting *SPWLA Today* as a new and separate publication was to capture the multiple topical, historical, geographical, educational, mentoring, and humanitarian functions of SPWLA with a flexible publication format subject to change and adjustment over time. Even though *Petrophysics* is already a well-established flagship technical publication, and *SPWLA Today* is still a publication with both format and content in continuing evolution, the former VP Publications thought that it would be useful to quantify whether SPWLA members were satisfied with both publications. We needed an objective way to assess whether the increase in publication expenses incurred by a greatly expanded *Petrophysics* journal and a fledging *SPWLA Today* newsletter was correlated with increased satisfaction by SPWLA members.

Method

The survey was designed to deliver a quantitative indication of the relative value and importance given to SPWLA publications as part of the benefits of SPWLA membership. Because of the various other benefits stemming from SPWLA membership, rather than obtaining an absolute result it was decided to compare the value of publications against (1) the Annual SPWLA Symposium, (2) Technical Webinars, (3) Talks by Distinguished Technical Speakers, (4) SPWLA-organized Technical Workshops, (5) SPWLA-organized Training Courses, (6) Regional Chapter meetings and workshops, (7) Special Interest Groups (SIGs) meetings and events, and (8) Access to SPWLA-based web resources. Accordingly, the survey consisted of eight questions (for each one of the above-cited items) requesting a satisfaction rating from 1 to 5, with 5 indicating the highest satisfaction and 1 the lowest. The survey was administered electronically only through email notification to all current SPWLA members.

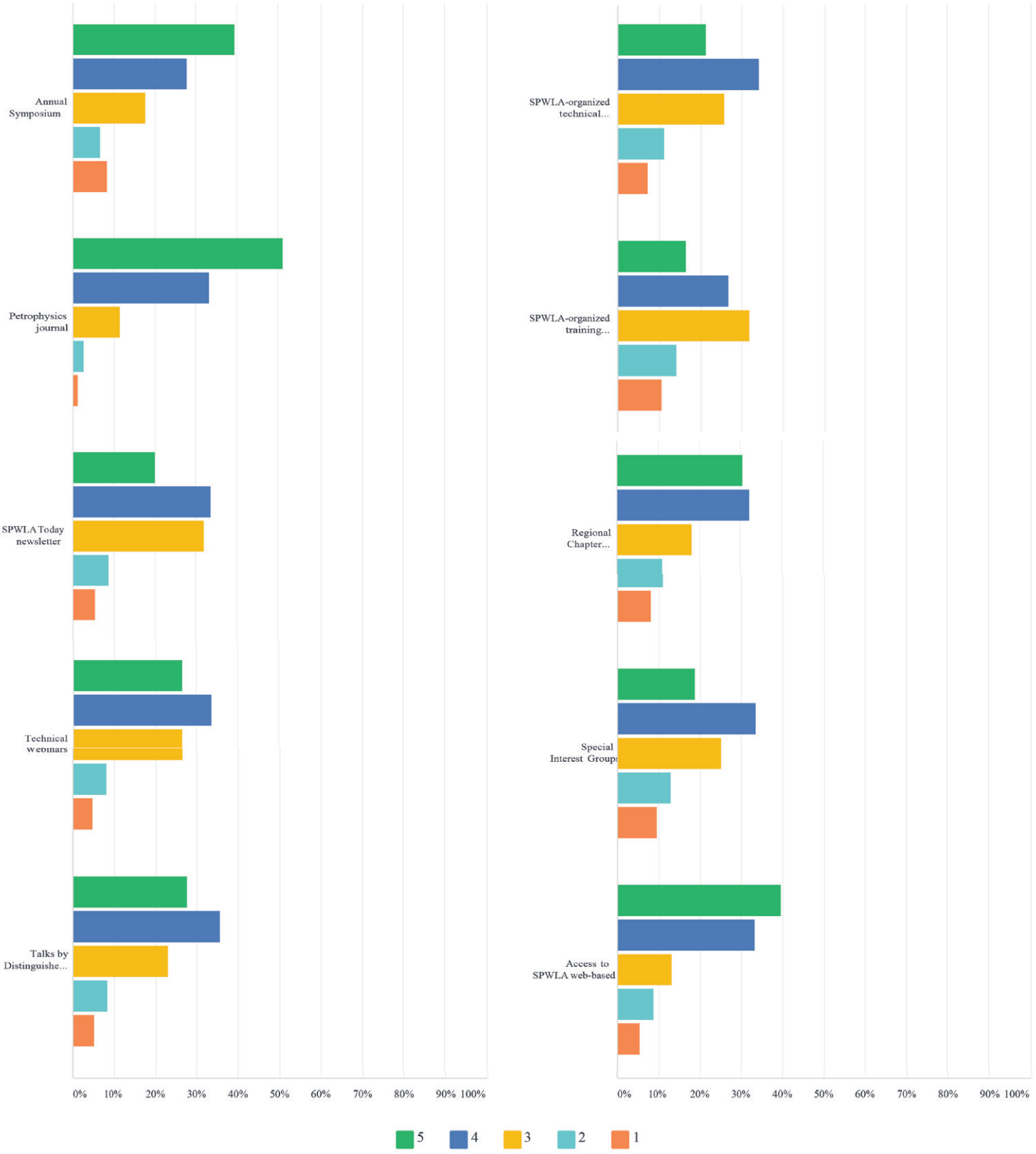
Results

Only 377 responses were received out of a total of 2,140 registered and voting SPWLA members. This number represents approximately one half of SPWLA members who cast a vote during the most recent Board elections, whereby the corresponding results serve only as a crude approximation of the pursued objective.

Results indicate that SPWLA members are very appreciative of *Petrophysics* as a membership deliverable. Overall, *Petrophysics* received the most appreciative votes among the 10 items considered in the survey. On the other hand, *SPWLA Today* appears to have similar membership appreciation value compared to most items other than *Petrophysics*, the SPWLA Annual Symposium, and access to SPWLA web-based resources. The fact that *SPWLA Today* does not yet stand out as clearly as *Petrophysics* as an important membership benefit is probably an indication of its fledging and still-changing format. However, it is also clear that SPWLA members do not think of *SPWLA Today* as invaluable or negligible as part of their SPWLA benefits. During the recent SPWLA Annual Symposium (June 2019) we received consistently very positive verbal feedback about *SPWLA Today*, especially among young members. We sense that the survey results indicate that there is no reason to abandon *SPWLA Today* as a membership benefit but they do indicate that we should strive for more organized and established content and format. We are surely taking heed of this in future endeavors.

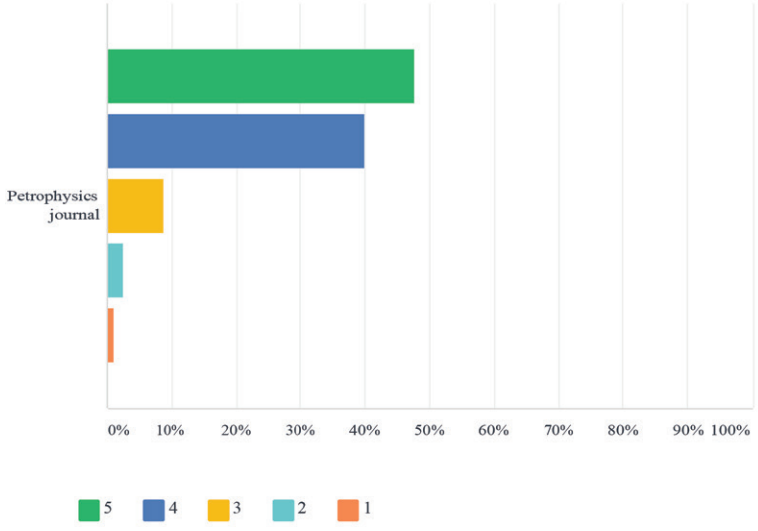
SPWLA 2019 Membership Benefits Survey Results

Question 1: Assign from 1 to 5 your personal relative value to the following SPWLA membership deliverables (5 is for highest satisfaction and 1 for lowest)
Answered: 377 Skipped: 1



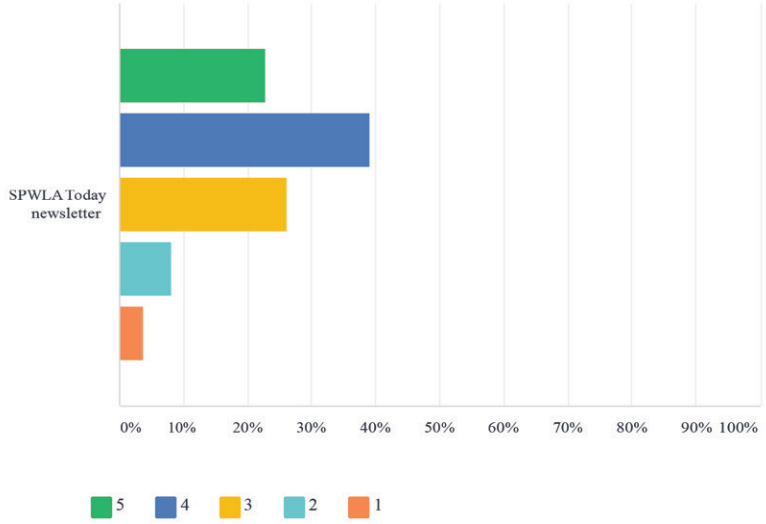
	5	4	3	2	1	TOTAL	WEIGHTED AVERAGE
Annual Symposium	39.44% 142	27.78% 100	17.78% 64	6.67% 24	8.33% 30	360	2.17
Petrophysics journal	51.33% 193	33.24% 125	11.44% 43	2.66% 10	1.33% 5	376	1.69
SPWLA Today newsletter	20.11% 73	33.61% 122	31.96% 116	8.82% 32	5.51% 20	363	2.46
Technical Webinars	26.63% 98	33.70% 124	26.63% 98	8.15% 30	4.89% 18	368	2.31
Talks by Distinguished Technical Speakers	27.72% 102	35.60% 131	23.10% 85	8.42% 31	5.16% 19	368	2.28
SPWLA-organized technical workshops	21.43% 78	34.07% 124	25.82% 94	11.26% 41	7.42% 27	364	2.49
SPWLA-organized training courses	16.48% 59	26.82% 96	31.84% 114	14.25% 51	10.61% 38	358	2.76
Regional Chapter meetings and workshops	30.49% 111	32.14% 117	18.13% 66	10.99% 40	8.24% 30	364	2.34
Special Interest Group (SIG) meetings and events	18.90% 69	33.42% 122	25.21% 92	12.88% 47	9.59% 35	365	2.61
Access to SPWLA web-based resources	39.51% 145	33.24% 122	13.08% 48	8.72% 32	5.45% 20	367	2.07

Question 2: On a scale from 1 to 5, indicate your current satisfaction and value as SPWLA membership deliverable with 5 being highest and 1 being lowest.
Answered: 373 Skipped: 5



	5	4	3	2	1	TOTAL	WEIGHTED AVERAGE
Petrophysics journal	47.72% 178	39.95% 149	8.85% 33	2.41% 9	1.07% 4	373	1.69

Question 3: On a scale from 1 to 5, indicate your current satisfaction and value as SPWLA membership deliverable with 5 being highest and 1 being lowest.
Answered: 370 Skipped: 8



	5	4	3	2	1	TOTAL	WEIGHTED AVERAGE
SPWLA Today newsletter	22.70% 84	39.19% 145	26.22% 97	8.11% 30	3.78% 14	370	2.31

ACOUSTICS SIG

Recent Events

15 June 2019 – The Acoustics SIG conducted a one-day workshop entitled "Practical Applications of Acoustics," in conjunction with the 2019 Annual Conference. This well-attended course was taught by SIG members from operators (Shell, Chevron) and service companies (Schlumberger, Haliburton, Lloyds Register) and was attended by SPWLA members from a wide variety of backgrounds. Topics covered included the application of borehole acoustics measurements to petrophysics, geomechanics and geophysics along with completions optimization and imaging. In line with the SIG's recent expansion to include casedhole acoustics, a session on cement evaluation and noise-detection methods was also included.

Acoustic SIG June 2019 Workshop. Philip Tracadas (Halliburton) delivering a talk on casedhole cement evaluation.

AUSTRALIA CHAPTER
(Formation Evaluation Society of Australia, FESAus)

General News

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

2019 Committee Members

President	Adrian Manescu
Vice President/ Assistant Treasurer/ Newsletter Coordinator	Wesley Emery
Company Secretary	Callum Rideout
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
Audio Visual Coordinator	Nigel Deeks
Sponsorship Coordinator/ Education Group Leader	Peter Havord
Sponsorship Coordinator	Andrea Paxton
Audio Visual Coordinator	Yang Xingwang
Victoria Representative	Matthew Durrant
NSW Representative	Harris Khan

Recent Events

14 May 2019 – The monthly technical meeting was conducted by Wayne Pennington (Dean and Professor Emeritus at Michigan Technological University) who spoke on "Our Evolving View of Time-Lapse Seismic Monitoring: 20 years of the same old Teal South Data." Wayne's talk was well received with a great deal of discussion and sharing of ideas.

FESAus May 2019 meeting. Wayne Pennington (Dean and Professor Emeritus at Michigan Technological University) (left) receiving speaker's gift from FESAus President Adrian Manescu (right).

11 June 2019 – The monthly technical meeting was conducted by Matthew Rigden, (Well Placement Engineer, Schlumberger) speaking on "Well Placement: Looking Ahead, The Future is Now." Matthew's talk was well received with a great deal of discussion and sharing of ideas.

FESAus June 2019 meeting. Matthew Rigden (left) (Schlumberger) receiving the speaker's gift from FESAus President Adrian Manescu.

Upcoming Events

09 July 2019 – Jennifer Market (MPC Kinetic) – Mining
13 August 2019 – Jone Slade (Woodside) – HPHT Logging
27 August – Steve Adams, Colin McPhee – TBA
06 September – New Technology Forum– Software
08 October – Vanessa Lim (Woodside) – TBA
12 November – Master Class – TBA
10 December – End of Year Xmas Luncheon, Jo Nova – Climate Change Talk

BANGKOK CHAPTER

General News:

The Bangkok Chapter of SPWLA holds Technical Meetings in Bangkok on the last Thursday of each month. Meetings are fully sponsored for SPWLA Members. There is no charge for nonmembers with email registration prior to the meeting. Students are always free of charge. Please visit https://www.spwla.org/SPWLA/Chapters_SIGs/Chapters/Asia/Bangkok/Bangkok.aspx for meeting information. Email: bangkok.chapter@spwla.org <bangkok.chapter@spwla.org>

2019 Chapter Committee Members:

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

Recent Events

30 May 2019 – Student Day. We had two excellent presentations by students from the Asian Institute of Technology (AIT) in Bangkok. The first was presented by Ms.Swanya Singim on "Construction and Application of Rock Physics Template for Characterization of Fractured Igneous Reservoirs in the Wichian Buri Basin, Thailand" and the second presentation was by Phatcharin Somkham on "Integrated Digital Thin Section and Multi-Mineral Model Analyses to Identify Rock Types of Fractured Igneous Rock Reservoirs in Phetchabun Basin."

27 June 2019 – Andrew Cox presented "Using Quantified 'Model Based' Petrophysical Uncertainty to Aid in Conflict Resolution." The talk was a case study highlighting the importance of identifying and quantifying uncertainties in petrophysical interpetations.

Bangkok Chapter May 2019. Student Presenters Phatcharin Somkham (left) and Swanya Singim (center) receive plaques for their presentations from Chapter President Andrew Cox.

Bangkok Chapter May 2019. Students from Asian Institute of Technology with SPWLA Bangkok Chapter Committee and members.

BOSTON CHAPTER

General News

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

Several Boston Chapter members presented at the recent 60th SPWLA Annual Symposium, in The Woodlands, Texas. The Chapter looks forward to welcoming 2019–2020 Distinguished Speakers to Boston soon.

Recent Events

19 April 2019 – the Chapter hosted Robert Kleinberg (Senior Fellow, Boston University Institute for Sustainable Energy and Senior Research Scholar, Columbia University Center on Global Energy Policy) for a jointly hosted event with SPE. He presented a lecture titled "Business Cycles and Innovation Cycles in the U.S. Upstream Oil & Gas Industry." The talk was highly informative and well attended.

BRAZIL CHAPTER

General News

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

Recent Events

26 March 2019 – We held the first meeting of the year: ZhanGuo Shi (Principal Petrophysicist and Wireline Domain Champion, Schlumberger) talked about "Minimizing Uncertainties by the Integrated Formation Evaluation." ZhanGuo Shi, who is based in Houston, spoke to a full room. The excellent talk was followed by a happy hour with the group.

Brazil Chapter March 2019 meeting. (left) ZhanGuo Shi (Schlumberger) and (right) Lenita Fioriti (Petrobras).

April 2019 – Jonatas Castor Einsiedler (Petrobras) delivered a great talk on the importance of quality control in NMR log interpretation.

Brazil Chapter April 2019 meeting. Jonatas Castor Einsiedler (Petrobras) giving his presentation.

21 May 2019 – Neyma Kurtz Azambuja (Petrobras) gave a presentation on the interpretation of formation tests in Pre-Salt wells and showed how a multidisciplinary approach can help adjust test results.

Brazil Chapter May 2019 meeting. Lenita Fioriti (Petrobras) (left) and speaker Neyma Kurtz Azambuja (Petrobras) (right).

ECC-SPWLA CHAPTER

April 15 to 18 2019 – The 5th National College Student Well-Logging Skills Competition was hosted by ECC-SPWLA eastern branch and China Petroleum Society at the China University of Petroleum (East China). The National College Student Well-Logging Skills Competition is jointly organized by ECC-SPWLA and China Petroleum Society and has been held annually since 2015 with the theme of promoting learning and teaching with the competition, so as to improve the organic combination of teaching well-logging basic theories and skills in universities and field operational needs.

The organizing committee invited 11 senior experts from China National Petroleum Corporation (CNPC), Sinopec, and China National Offshore Oil Corporation (CNOOC) as referees, of which Dawei Lu, the former director of the Petroleum Well Logging Commission, served as the head referee. The examination questions were set by the Petroleum Well Logging Commission. Ciflog 2.1 (CNPC Research Institute of Petroleum Exploration and Development) and Lead 3.5 (CNPC Logging) were designated as the competition well-logging software. In addition, Suzhou Niumag (Analytical Instrument Corporation) provided related technical support. SPWLA President Zhipeng Liu expressed congratulations on the competition and offered some valuable suggestions.

Following the preliminary selection, 36 teams, four members of each team, were chosen out of 17 universities, including China University of Petroleum (East China), China University of Petroleum (Beijing), Jilin University, Tongji University, Yangtze University, Southwest Petroleum University, Northeast Petroleum University, China University of Geosciences (Beijing), China University of Geosciences (Wuhan), Chang'an university, East China University of Technology, Xi'an Shiyou University, Northwest University, Chengdu University of Technology, Xi'an University of Science and Technology, China University of Petroleum Shengli College, and Chongqing University of Science and Technology. The participating teams are divided into undergraduate and graduate groups, in particular, the graduate team from Tongji University consists of three foreign students and one Chinese student.

The final comprised four parts: field log-data processing, a theoretical examination, knowledge answering, and presentation. Participants were asked to complete the field-data processing within nine hours, which involved

data processing, log interpretation, and exporting the results to investigate student's ability to process different types of logging data and the comprehensive interpretation and evaluation. The theoretical examination is designed to test the students' basic knowledge. The knowledge answering session includes well logging, drilling, mud logging, oil testing, and wellsite operation. The last part is the presentation with a focus on the ability to understand data processing and analyze problems.

After three-days of fierce competition, the teams from China University of Petroleum (East China), China University of Petroleum, Jilin University, and Chang'an University won the special prize for the undergraduate and graduate groups, and the other 16 teams gained first and second prizes, respectively. At the same time, the Committee also ranked the best theory awards, the best answering awards, the best defense awards, and so on.

During the competition, the forum on well-logging discipline and professional construction was held. Teachers and field experts conducted extensive discussions and communication on well-logging graduate students training, training of a student's practical ability, well-logging discipline development, development environments for young teachers, the cooperation and exchanges between universities, and so on, and reached many important consensuses.

ECC Chapter April 2019. National College Student Well-Logging Skills Competition group photo.

ECC Chapter April 2019. National College Student Well-Logging Skills Competition group photo.

ECC Chapter April 2019. National College Student Well-Logging Skills Competition knowledge testing.

ECC Chapter April 2019. National College Student Well-Logging Skills Competition closing ceremony.

Upcoming Events

24 to 27 September 2019 – The 11st UPC International Symposium on New Well Logging Techniques: Petrophysics and Logging Big Data

FRANCE CHAPTER
(Société pour l'Avancement de l'Interprétation des Diagraphies, SAID)

Recent Events

17 April 2019 – Alberto Ortiz (YPF Argentina), SPWLA regional distinguished speaker, gave a presentation at the Schlumberger office (Auditorium Le Palatin) in Paris at an afternoon technical session entitled "Formation Evaluation in Unconventionals." Alberto presented an overview, from an operator's perspective, on exploration and development of the Vaca Muerta shale play. His introductory talk was followed by five presentations, grouped in two subtopics about Organic Matter Characterization and Unconventional Play Evaluation, which mixed petrophysics, basin modeling, geomechanics, laboratory and log formation evaluation from diverse points of view: consultant, operator and service company. The session was well attended and, as usual, remotely accessible in parallel via weblink. The session program follows.

Keynote Speech

Alberto César Ortiz (YPF), SPWLA Regional Distinguished Speaker – "What Have we Learned From the Petrophysical Evaluation of the Vaca Muerta Formation During the Last Five Years of Unconventional Shale Play Exploration and Development?"

Organic Matter Characterization

Benjamin Nicot (TOTAL) – "Estimating Saturations in Organic Shales Using 2D NMR."

Laurent Mossé (Schlumberger) – "Fluid Typing and Maturity Index From Logs: A New Framework for Petrophysical Evaluation of Organic-Rich Mudrock."

SAID April 2019 meeting. (Left) Handshake between Chapter Vice President Jacques Delalex congratulating speaker Alberto César Ortiz (YPF) after his presentation; (right) Laurent Mossé (Schlumberger) presented a new framework for petrophysical evaluation of organic-rich mudrock.

Unconventional Play Evaluation

Martin Neumaier (Consultant) – "The Battle of Scales—Can we Predict Shale Gas Saturation Logs Based on Petroleum Systems Modeling?"

Anton Padin (TOTAL) – "Geomechanical Characterization of Unconventional Formations: A Key for SRV Creation and Production."

Ishan Raina (SLB MpTC) – "Quantifying Water Saturation in a Source Rock Gas Play Using Multi-Frequency Dielectric Measurements"

Martin Neumaier (Consultant)

Anton Padin (TOTAL)

Ishan Raina (SLB MpTC)

This meeting was also the occasion to thank our chapter secretary, Sylvain Boyer, who has just retired from IFP School (French Institute of Petroleum) and has started a new life in the South of France. Sylvain has been a SAID (then SPWLA France) board member for about 30 years and held the positions of Secretary, Technical Secretary and President (2003–2005). Sylvain was the meritorious writer of a number of the well-known *Lettres de la SAID* (SPWLA France letters), edited until 2016 for about 39 years. As IFP school teacher, Sylvain has probably trained a whole generation of log analysts in France and around the world. The whole SPWLA France Chapter board thanks Sylvain for his contribution to the petrophysical society, his involvement to SPWLA France Chapter and wishes him a quiet and peaceful retirement in the charming French Provence.

SAID April 2019 meeting. (Left to right) Jacques Delalex (Consultant – SPWLA France Vice President), Sylvain Boyer (IFP-School – SPWLA France Secretary), Jean-Etienne Jacolin (Schlumberger MpTC – SPWLA France Treasurer), and Olivier Marché (Schlumberger – SPWLA France Technical Secretary).

LONDON CHAPTER
(London Petrophysical Society, LPS)

General News

The SPWLA recently awarded the LPS the 'Outstanding Chapter Award' for 2018–2019! This was presented at the 60th SPWLA Annual Symposium in Woodlands, Texas. Thanks to everyone that has been involved with the LPS recently, or with hosting the London SPWLA Symposium last year; this award is a much- deserved recognition of all your hard work.

Recent Events

21 May 2019 – Iulian Hulea (Shell) spoke about "Understanding Fundamental Controls of Hydrocarbon Saturation: From Stress Corrections to Perched Water Contacts," which sparked some great technical discussion. Huge thanks to Iulian and to all who attended for their questions and debate.

20 June 2019 – We held an excellent One-Day Seminar on "Image Logs and Fractured Reservoirs," in the Janet Watson lecture theatre at the Geological Society. Many thanks to all who participated and especially to our speakers for giving up their time and making it a great day.

Upcoming Events

23 July 2019 – Evening lecture by Neil Bonwick (Ikon Science) on "Digital Transformation of the Subsurface."

12 September 2019 – One-Day Seminar on "Life After Casing"

15 October 2019 – Evening lecture by Ebrahim Heydari (Independent) on "Rock Typing: Application in Reservoir Modelling And Development."

12 November 2019 – AGM and off-topic talk.

05 December 2019 – One-Day seminar on "Saturation Height" – followed by President's evening

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

THE NETHERLANDS CHAPTER
(Dutch Petrophysical Society)

Recent Events

06 June 2019 – The DPS held its Annual General Meeting and a seminar on "Improved tight gas reservoir description". Professor Quentin Fisher (Leeds University) presented on "Petrophysical Properties of Tight Gas Sandstones," while Marten Bron (Wintershall Nordzee) presented on "Integration of Various Study Results for Improved Tight Gas Reservoir Description." The meeting was well attended, and the audience engaged in lively discussion on both topics during and after the talk. DPS would like to thank all attendees and both speakers for an inspiring session.

DPS Jue 2019 meeting. Part of the engaged audience during the meeting.


DPS June 2019 meeting. Iulian Hulea (DPS president) presenting the speakers Quentin Fisher (left) and Marten Bron (right) with a token of appreciation from the DPS.

PDDA SIG

General News

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), and Siddharth Misra (The University of Oklahoma)

The PDDA SIG board passed a vote to set up a scholarship foundation of $1,000 for one graduate student doing relevant research. **Applicants should send a resume to pdda_sig@spwla.org together with a reference letter from their advisors before October 1, 2019.**

Recent Events

20 June 2019 – The SPWLA PDDA SIG held its 1st annual meeting on June 20 following the conclusion of the SPWLA Annual Symposium. The meeting was fully registered by 50 attendees from major and independent oil companies, service companies, technology startups, and universities. The meeting consisted of a wide-ranging set of talks (see program below) that spanned many aspects of how analytics can be leveraged to enhance petrophysical data quality and analysis. We had lively discussions about potential future developments for using analytics In the keynote talk, Mr. Hani shared some interesting future developments in the field of machine learning with the advent of edge computing, cloud, and digital twins. The talks on image analysis (SEM images, borehole resistivity images, and micro-CT images) using machine learning were well received. Another thought-provoking talk was on use of deep learning for well-log correlation on scale that led to interesting conversations during the Q&A. The message that reverberated across all the talks was that the analytical techniques can very well answer the challenging petrophysical questions only when the problem is well defined and good quality data are available from various sources/disciplines. It is evident from the talks presented at the SPWLA Annual Symposium that data analytics and machine learning will help petrophysicists, engineers and geoscientists to improve their productivity and generate insights from large datasets.

Time	Speaker	Affiliation	Topic
7:30 AM			Breakfast and Registration
8:00 AM	Chicheng Xu	Aramco	Welcome & Introduction
8:10 AM	Hani Elshahawi	Shell	Keynote talk: "Silo Busting - How Data Analytics is helping Petrophysics integrate with other disciplines
8:40 AM	Philippe Herve	SparkCognition	Predicting petrophyscis, reservoir characteristic, and drilling dysfunctions with AI powered automation
9:10 AM	Bin Dai	Halliburton	Machine learning and pattern recognition for formation testing and sampling
9:40 AM	Michael Ashby	Anadarko	Petrophysics-Driven Well Log Quality Control Using Machine Learning
10:10 AM			Break
10:30 AM	Chicheng Xu	Aramco	When Petrophysics Meet Big Data: What can Machines Do?
11:00 AM	Tianqi Deng	University of Texas, Austin	Comparative Study of Three Supervised Machine-Learning Algorithms in Classifying Diagenetic Facies in the Kansas Arbuckle Carbonate Formation
11:30 AM	Constantine Vavourakis	Emerson	Limitations of Naïve Machine Learning Approaches in Geosciences: The Example of Grain Size Prediction from Microresistivity Logs
12:00 PM			Lunch
1:00 PM	Constantine Vavourakis	Emerson	Machine Learning Development in Geolog: Leveraging Deep Learning Techniques for Improved Log Prediction
1:30 PM	Alex Bayeh	Anadarko	A Deep Learning Model and Framework for Well Log Correlation at Scale
2:00 PM	Siddharth Misra	University of Oklahoma	Machine learning for SEM image analysis
2:30 PM			Break
3:00 PM	James Howard & Shawn Zhang	DigiM Solution	Machine-Learning Methods: Analysis of Rock Images and Beyond
3:30 PM	Xicai (Jack) Liu	Consulting Engineer (previous Sinopec)	Determination of Shale Anisotropic Properties and Applications
4:00 PM	Bin Dai	Halliburton	Closing Remarks

SAUDI ARABIA CHAPTER

Recent Events

30 April 2019 –SPWLA Saudi Arabia held its 6th topical workshop on "Deep-Sensing Petrophysics" in Al Khobar, Saudi Arabia. Mr. Khalid Zainalabedin, manager of the Reservoir Description and Simulation Department at Saudi Aramco, opened the workshop by stressing the importance of sensing the reservoirs deep, through accurate reservoir characterization, mapping and monitoring. The goal is to reduce the uncertainties in hydrocarbon localization deep into the reservoirs, enhance confidence in production forecasts and maximize hydrocarbon production.

The morning session was dedicated to electromagnetic (EM) technologies. Alberto Marsala (Saudi Aramco) discussed the need for continuous investment in research and development of deep-sensing EM techniques, along four strategic pillars of transmission, acquisition, processing and interpretation. Jonathan Hall (Weatherford) gave an overview of other deep-sensing techniques including chemical tracers and noise logging. Ping Zhang (Schlumberger) presented crosswell EM technologies for reservoir monitoring. Gary McNeice (Saudi Aramco) discussed the experience of Saudi Aramco with Surface-to-Borehole controlled-source EM technologies, while Quintilio Vasquez (Halliburton) gave an overview of a borehole-to-surface EM measurement. During the break, Ping Zhang presented a poster on electrical resistivity tomography and Ahmed Abouzaid (BHGE) presented a poster about acoustic deep shear wave imaging.

The afternoon session was dedicated to deep-sensing well placement. Asim Mumtaz (BHGE) opened the session with a review of deep-sensing petrophysics applications and advancements in the well-placement domain. Rajeev Samaroo (Schlumberger) presented an application on how to upscale and calibrate petrophysical models using deep-reading LWD data. Bronwyn Djefel (Halliburton) presented the last talk on a new 3D inversion of LWD deep azimuthal resistivity data. The audience was then divided into groups and group discussions were guided by questions summarized from the technical talks. Marie Van Steene (Schlumberger) conducted an interactive quiz to enhance learning, before Faisal Enezi (Saudi Aramco), the chapter president, closed the workshop, an indeed very successful one with more than 100 participants.

SPWLA Saudi April 2019 6th topical workshop on "Deep-Sensing Petrophysics."A token of appreciation presented to the keynote speaker Mr. Khalid (center) by SPWLA Saudi Chapter SAC committee.

SPWLA Saudi April 2019 6th topical workshop on "Deep-Sensing Petrophysics" group photo.

UNIVERSIDADE FEDERAL DO RIO DE JANEIRO (UFRJ) STUDENT CHAPTER

General News

After introducing the chapter to the freshmen, we held our selection for new members. And began to plan the 2019 SEGEP Workshop, our largest event, together with the AAPG UFRJ Student Chapter.

Recent Events

08 May 2019 – Selection of members.

Marketing Team	Rodrigo Azambuja, Amanda Bezerra and Bruno Valle
Logistic and Events team	Caio Guedes, Isabelle Freitas and Vinicius Jorge
Financial Assistant	Leonardo Ribeiro

20 May 2019 – Election of new board members

President	Teresa Mourão
Vice President	Leticia Cardoso
Treasurer	Sofia D'Orsi
Secretary	Maria Eduarda Verbicário

28 May 2019 – Lecture by Giovanna Carneiro (Schlumberger) on "The Applications of Nuclear Magnetic Resonance in Petrophysics

THE UNIVERSITY OF TEXAS AT AUSTIN STUDENT CHAPTER

General News

The Student Chapter of SPWLA at UT-Austin was very well represented at the 60th SPWLA Annual Logging Symposium in the Woodlands. Chapter members authored or coauthored 20 out of the 137 oral and eposter presentations that were included in the conference's main technical program. Our chapter's 2018–2019 president Artur Posenato Garcia, chapter members Chelsea Newgord and Archana Jagadisan all received the 2018–2019 SPWLA Distinguished Speaker awards.

In addition, our chapter's nominee for the SPWLA International Student Paper Contest, Sercan Gul, won 1st place at the PhD level for his presentation entitled "Automated Surface Measurements of Drilling Fluid Properties: Field Application in the Permian Basin." Congratulations to Sercan!

Finally, the Student Chapter of SPWLA at UT-Austin received the 2018–2019 Outstanding Student Chapter Award during the SPWLA Awards Presentation on June 18. We are extremely grateful for this award. Moreover, we would like to express our gratitude to everyone that has contributed to the chapter's past and present success, to all the present and past officers who volunteered to our chapter, to the SPWLA Houston Chapter, to Jeff Crawford, Tianmin Jiang, Katerina

Yared, Adam Haecker, to our chapter adviser Dr. Carlos Torres-Verdin, all the volunteers who contributed to the success of our events, to Shell, Schlumberger, Marathon Oil Corporation. Most importantly, we would like to thank all the speakers who dedicated their time to present their work in Austin during the 2018–2019 cycle: Shahid Haq, Javid Shiriyev, Runqi Han, Aidan Blount, Dzevat Omeragic, Hani Elshahawi, SPWLA 2019–2020 president Jesus Salazar, Carl Fredrik Berg, Paul Craddock, and Stefan Hertel.

Thank y'all and hook'em!

UFRJ May 2019 meeting. SEGEP 2019 team with speaker Giovanna Carneiro (Schlumberger). Left to right: Bruno Valle, Maria Eduarda, Leonardo, Teresa, Fernanda, Giovanna, Sofia, Isabelle, Amanda and Caio;

Sercan Gul, SPWLA International Student Paper Contest 1st place winner at the PhD level, presented his work "Automated Surface Measurements of Drilling Fluid Properties: Field Application in the Permian Basin," at UT Austin.

Alain Brie
1948–2019

It is difficult to write a short eulogy about Alain's history. After receiving a diploma from ENSI Poitiers, Alain was hired by Schlumberger and began his training in Angola in the early 1970s. It was a difficult baptism of fire, quickly followed by tough assignments in Nigeria, Congo, Gabon and Libya. He was then sent to Venezuela and Mexico. He was transferred to the Overseas headquarters in Paris, where he worked on medium frequency electromagnetics, a field that has been further developed in recent years. He then served as one of the first managers to lead the famous Schlumberger LAT (Log Analysis Training) school that subsequently trained hundreds of employees in log analysis. Following this assignment, he spent time at Schlumberger-Doll Research in Ridgefield, Connecticut, and at Schlumberger's facility in Fuchinobe, Japan, where he became the leading expert in acoustic logging. He produced dozens of technical articles that are often cited. He was well known as Mr. Sonic, a person who could discuss sailing, water skiing and acoustic logging with equal relevance and competence.

Alain was also well known for (1) his special kind a humor (Alison Goligher, a colleague, defined his style as friendly naughtiness), and (2) his unlimited energy. Only recently, he was excelling in off-track skiing, was running on the sand of the nearby beach and dancing to Beatle's tunes.

Marcel Proust wrote that the real death comes up when nobody in the universe remembers you. For Alain, this will not come for very long time.

Condolences to his wife Jacqueline and to daughters Celine and Florence.

Philippe Theys

Welcome New Members–April 15, 2019–June 24, 2019

Aasen, Kristofer, Texas Tech University, Hayfield, MN, United States
Aboujmeih, Hassan, ADNOC Offshore, Abu Dhabi, United Arab Emirates
Ahmadirad, Babak, University of Houston, Houston, TX, United States
Al Blooshi, Asma, ADNOC Offshore, Abu Dhabi, United Arab Emirates
Al Mamari, Ayoub Saif Humaid, Colorado School of Mines, Golden, CO, United States
Al Maskari, Shaymaa, ADNOC Onshore, Abu Dhabi, United Arab Emirates
Al Salati, Alya, ADNOC, Abu Dhabi, United Arab Emirates
Al Zaabi, Fatema, ADNOC, Abu Dhabi, United Arab Emirates
Al-Hilali, Mazin, Oilserv, Bahrka, Erbil, Iraq
Alali, Abdulkarim, Tatweer Petroleum, Awali, Southern, Bahrain
Albadi, Abeer, ADNOC, Abu Dhabi, United Arab Emirates
Alkhoori, Aysha, ADNOC, Abu Dhabi, United Arab Emirates
Arkalgud, Ravi, Helio Flare Ltd, ABERDEEN, United Kingdom
Audu, Abraham, University of Exeter, Erith, United Kingdom,
Aux Millan, Julián, Universidad Industrial De Santander, Bucaramanga, Santander, Colombia
Avilez, Samuel, TGT Oil and Gas, Greensburg, PA, United States
Banothu, Babu, ONGC, Mehsana, Gujarat, India
Bezerra, Amanda, UFRJ, Rio De Janeiro, Brazil
Biancardi, Cerys, Cardiff University, Cardiff,United Kingdom
Bini, Luis, University of Houston, Houston, TX, United States
Bittar, Michael, University of Houston, Houston, TX, United States
Brackenridge, Ross, Lloyd's Register, Aberdeen, United Kingdom
Brasil Caires, Aline, Petrobras, Rio De Janeiro, Brazil,
Carlson, Thomas, Texas Tech University, Lubbock, TX, United States
Chen, Huangye, EXxonmobil, Cypress, TX, United States
Chen, Meng, Southwest Petroleum University, Chengdu, Xindu, China
Chohan, Mohammad, BHGE, Houston, TX, United States
Chuilon, Pierre, Total SA, Pau Cedex, France
Collins, Andrew, Schlumberger, Missouri City, TX, United States
Dua, Ajay, ADNOC, Abu Dhabi, United Arab Emirates
Ekechukwu, Gerald, University of Wyoming, Laramie, WY, United States
Esmaeilpour, Misagh, Kansas State University, Manhattan, KS, United States
Evraets, Bradly, PDC Energy, Arvada, CO, United States
Firdaus, Miftahul, ConocoPhillips Indonesia, Jakarta, Indonesia
Garcia, Alex, Baker Hughes, a GE Company, Houston, TX, United States
Gasparotto, Andrea, University of Southampton, Southampton, Hampshire, United Kingdom
Gragg, Evan, SM Energy Company, Denver, CO, United States
Hamza, Muhammad, Lahore, Pakistan
Hargrove, Brendan, Oasis Petroleum, Houston, TX, United States
Ho, Hung Kai, Texas Tech, Lubbock, TX, United States
Hu, Jianxiong, Southeast University, Nanjing, China,
Ihunde, Thelma, Louisiana State University, Baton Rouge, LA, United States
Jiang, Xiaowen, Southeast University, Nanjing, China
Jin, Yuchen, University of Houston, Houston, TX, United States
Johnson, Megan, Petrophysical Solutions, Inc., Cypress, TX, United States
Jun, Zhu, CNPC Logging Co, China
Jutila, Heikki, Phoenix RDS Ltd, Aberdeen, United Kingdom
Kazmi, Syed Asad Ali, Weatherford, Islamabad, Capital, Pakistan
Kenter, Jeroen, TOTAL, Jurancon, Acquitaine, France
Khache, Inayatullah, ADNOC, Abu Dhabi, United Arab Emirates
Kumar, Abhishek, University of Houston, Houston, TX, United States
Kumar, Sandeep, ONGC, Mehsana, Gujarat, India
Kumar, Sourav, ONGC, Mehsana, Gujarat, India
Laer, Pierre, ADNOC, Abu Dhabi, United Arab Emirates
Layden, Andrew, University of Oklahoma, Spring, TX, United States
Li, Guo-Shi, ExxonMobil, Spring, TX, United States
Li, Hu, Maxwell Dynamics, Inc, Katy, TX, United States
Liu, Siyan, University of Kansas, Lawrence, KS, United States
Lopez, Janett, Texas Tech University, New Caney, TX, United States
Lukaszeski, Zachary, University of Louisiana at Lafayette, Memphis, TN, United States
Mahmood, Md Nahin, University of Louisiana at Lafayette, LA, United States
Marchant, David, Computational Geosciences Inc, West Vancouver, BC, Canada
Mazumdar, Aryab, University of Houston, Houston, TX, United States
McVey, Billy, Texas Tech University, Trinity, TX, United States
Yakup, Azwan, Tutong, Brunei Darussalam
Meena, Ghanshyam, ONGC, Mehsana, Gujarat, India
Miller, Mark, Baker Hughes / GE, Houston, TX, United States
Mohamed, Mohamed Ibrahim, Colorado School of Mines, San Antonio, TX, United States
Moir, Nicholus, California Resources Corporation, Bakersfield, CA, United States
Montero, Jose, University of Leeds, Abingdon, Oxfordshire, United Kingdom
Moosavi, Syed, Rice University, Richmond, TX, United States
Mouici, El-djoudi, BHGE, Houston, TX, United States

Nooner - Hill, Nicole, Stratum Reservoir, Houston, TX, United States
Nwankwo, Godswill, University of Houston, Houston, TX, United States
Osogba, Oghenekaro, University of Oklahoma, Norman, OK, United States
Popa, Cristian, Mazarine Energy, Bucharest, Romania
Pryporov, Maksym, Occidental Petroleum, Katy, TX, United States
Rahmatian, Mansour, Core Mineralogy Labs, Broussard, LA, United States
Raines, Jessica, Baker Hughes, a GE Company, Houston, TX, United States
Reynolds, Amanda, Encino Energy, Houston, TX, United States
Ribeiro, Leonardo, Universidade Federal Do Rio De Janeiro, Rio De Janeiro, Brazil,
Rothe, Eric, Baker Hughes, a GE Company, Houston, TX, United States
Sakiyama, Naoki, Schlumberger, Houston, TX, United States
Sánchez, Brayhan, Universidad Industrial De Santander, Bucaramanga, Santander, Colombia
Schwartz, Bryan, ExxonMobil, Spring, TX, United States
Soliman, Bahaa, Schlumberger, Alexandria, Egypt
Soto, Manuel, Repsol, Madrid, Spain
Souza, Andre, Petrobras, Rio De Janeiro, Brazil
Srivastava, Nikhil, ONGC, Mehsana, Gujarat, India
Staruiala, Adam, NCS Multistage, Calgary, AB, Canada
Suarez, Leonardo, Halliburton, Rio De Janeiro, Brazil,
Sumarna, Fabian, Curtin University, Bentley, WA, Australia
Tahani, Hoda, Halliburton, Houston, TX, United States
Techeira, Rebecca, GeoMark Research, Houston, TX, United States
Tiwari, Babita, ONGC, Ankleshwar, India,
Tohill, Bosco, Schlumberger, Bucharest, Romania
Tost, Brian, Oregon State University, Lebanon, OR, United States
Ugonoh, Mohammed, ADNOC, Abu Dhabi, United Arab Emirates
Vannicola, Mary, Equinor, Cypress, TX, United States
Viator, David, ExxonMobil, Spring, TX, United States
Wang, Shirui, University of Houston, Houston, TX, United States
Watt, Adam, Heriot Watt University, Ellon, Aberdeenshire, United Kingdom
Wedberg, Torolf, Smartfeatures, Bergen, Norway,
Wiseman, Mark, Anadarko, Cypress, TX, United States
Wu, Xuqing, University of Houston, Houston, TX, United States
Yousif, Shaifa, ADNODC, Abu Dhabi, United Arab Emirates,
Zhang, Jing, University of Oklahoma, Norman, OK, United States
Zhou, Xin, Schlumberger, Tianjin, China
Zhou, Yuhai, Texas A&M University, College Station, TX, United States