SPWLA France Chapter

Section française de la SPWLA "Society of Petrophysicists and Well Log Analysts"

TECHNICAL SESSION:

Formation Evaluation in Unconventional
Evaluation des formations en non conventionnel

Wednesday, April 17th 2019, 13:30-17:30

Auditorium Le Palatin - Schlumberger Office
1, cours du Triangle, 92936 La Défense Cedex

Pour participer à une session technique :

Vous pouvez soit être présent , soit suivre les présentations par Skype Web link.
Aucune participation financière n'est requise. Pour cela, vous devez, au préalable, si vous n'êtes pas membre de la SPWLA en 2019, simplement vous inscrire sur le site de la SPWLA https://www.spwla.org/ : cliquez sur "**Membership**" et sélectionnez: « **Become a Chapter affiliate** », entrez vos coordonnées et sélectionnez le chapitre « SAID (France) ». Vous devenez alors gratuitement membre affilié à SPWLA France.
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You can either be present at the location of the meeting or follow the lectures via a Skype Web link.
*The session is free. If you are not member of SPWLA in 2019, you have to register first on the SPWLA web site https://www.spwla.org/, click on "**Membership**" and select « **Become a Chapter affiliate** »; Complete the information requested and select the chapter "SAID (France)". You become affiliate member of SPWLA France for free.*
Then, to register to a technical session, just send an email at vice-president@spwla-france.fr with name, company, position. Mention if you will be present or will follow the lectures via Skype Web link. In the second case, an invitation will be sent 2 or 3 days before the session starts .

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Programme effectif / Effective *Program*

13:30 - 13:45	***Welcome, Safety and preliminary remarks .***	E. Caroli, President

SPWLA Distinguished Speaker

13:45 - 14:25	***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 ?***	Alberto César Ortiz YPF

Organic matter characterization

14:15 - 14:40	***Estimating Saturations in Organic Shales Using 2D NMR (Cancelled due to flight cancellation from Pau and Web link problem)***	Benjamin Nicot TOTAL
14:40 - 15:05	***Fluid typing and maturity index from logs: A new framework for petrophysical evaluation of organic-rich mudrock***	Laurent Mossé Schlumberger

Unconventional play evaluation

15:05 - 15:40	***The battle of scales – Can we predict shale gas saturation logs based on petroleum systems modelling?***	Martin Neumaier Consultant
15:40 - 15:50	***Thanks to Sylvain Boyer , Past President and Secretary of S.A.I.D for 30 years service for S.A.I.D., France SPWLA Chapter***	Jacques Delalex , VP
15:50 - 16:20	**Pause / *Break***	
16:20 - 17:00	***Geomechanical characterization of unconventional formations: a key for SRV creation and production***	Anton Padin TOTAL
17:00 - 17:25	***Quantifying Water Saturation in a Source Rock Gas Play Using Multi-Frequency Dielectric Measurements***	Ishan Raina SLB MpTC
17:25 - 17:30	**Clôture de la session */ Session closure***	J. Delalex , VP

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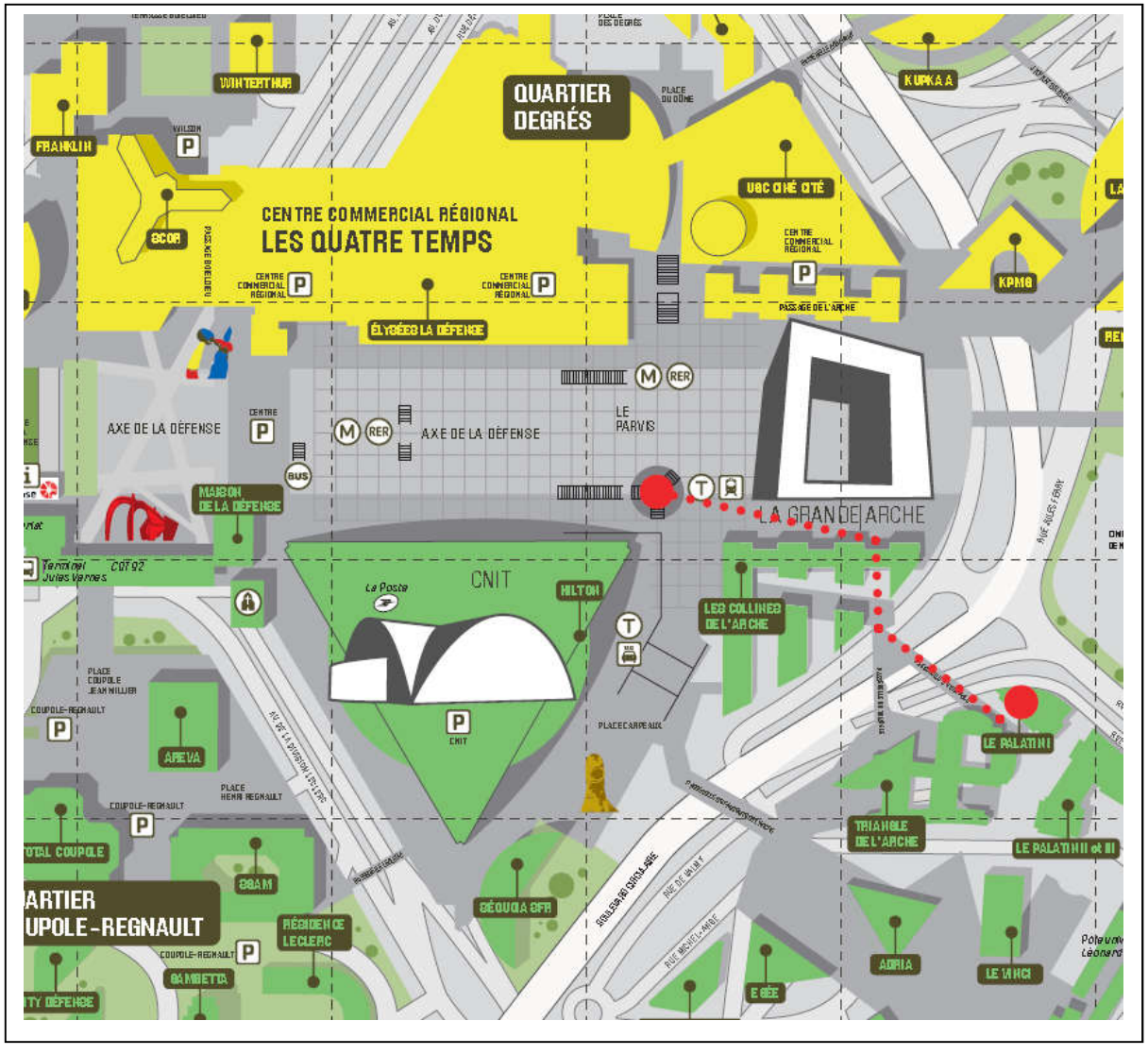

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Résumé des présentations / *Abstracts*

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 ?,
Alberto César ORTIZ, YPF

The Vaca Muerta formation is one of the unconventional shale play reservoirs considered a "world-class reservoir". Its thickness opens the possibility to develop the reservoir by the vertical stacking of more than one horizontal well. Petrophysical and geomechanical evaluations are required to identify the landing point of each well, however their characterization is complex and has progressed through time gaining complexity and detail.
The current petrophysical models consist in the definition of nine minerals, kerogen volume and total porosity using triple combo data, nuclear spectroscopy and nuclear magnetic resonance logs. The petrophysical interpretation obtained by logs is supported by core data and their calibration was achieved only after a comprehensive understanding of the advantages and limitations of the involved measurements. The estimation of total water by resistivity-free methods was another technical challenge achieved considering the problems of using induction logs for this purpose.
The formation evaluation with logs also allows the characterization of the hydrocarbon and kerogen properties as a function of maturity. This is because both components represent a large portion of the rock volume in Vaca Muerta. The maturity effect can also be verified with core data (Tight Rock Analysis, Dean Stark and Nuclear Magnetic Resonance).
Today, it is possible to characterize the variability of the poral & fluid system associated by using Scanning Electron Microscope and Nuclear Magnetic Resonance logs. These techniques could help resolve the upscaling problem of these shale plays and opens the door for a more accurate and detailed understanding of the reservoir..

Estimating Saturations in Organic Shales Using 2D NMR, Benjamin NICOT, TOTAL

An accurate evaluation of water and oil saturations has appeared more challenging in tight organic shales than in conventional reservoirs. In this paper, we describe a nondestructive method allowing the measurement of hydrocarbon saturation based on 2D T1-T2 NMR.
First, we give experimental evidence of an NMR contrast between oil and water in organic shales. Contrary to the condition in conventional reservoirs, the contrast between oil and water in shales is not based on diffusion, but on the T1/T2 ratio. Various imbibition tests with water/light oil/D2O were performed. These tests prove that the oil and water NMR signals can be assigned unambiguouslyin 2D T1-T2 NMR maps. They also prove that the high T1/T2 in organic pores is not due to bitumen (high viscosity), and that it can be achieved by light oil (isopar L). The high T1/T2 observed is only due to confinement in the organic pores.
Secondly, multifrequency NMR dispersion (NMRD) experiments were used to understand how confinement only can lead to such a high T1/T2. These experiments allow us to propose an interpretation that explains the unexpected dynamical behavior of the light oil in organic pore leading to high T1/T2. Finally, water and oil volumes measured by 2D T1-T2 NMR were validated by thermogravimetric analysis (TGA).

Fluid typing and maturity index from logs: A new framework for petrophysical evaluation of organic-rich mudrock, Laurent MOSSE, Schlumberger

Thermal maturity is an important parameter for shale play evaluation. It impacts many reservoir properties including kerogen composition, kerogen density, bitumen content, the type of producible hydrocarbon, porosity, pore-size distribution, water saturation, and clay type.

Accounting for thermal maturity is of prime importance while estimating formation volumes in place, because kerogen and hydrocarbon properties (density, hydrogen and carbon weight fractions) required for accurate volumetric estimates depend on this factor. Presently, analysts fix those properties based on a-priori knowledge and experience. Maps of play maturity exist, but they are approximate and usually do not encompass vertical variations.

A new interpretation framework is presented here. It is an evolution of a volumetric solver such as ELAN where kerogen and hydrocarbon properties are not fixed, but are inverted for at each depth, under certain constraints. Natural variability of these properties can then be determined, both vertically and laterally, and a more accurate volumetric estimation is achieved.

Key components of the new framework are property models for kerogen and hydrocarbon. They provide quantitative relationships between thermal maturity, density, hydrogen and carbon weight fractions of these components. The property models can also be used as guide for analysts using more classic evaluation workflows. These models will be presented and devised during this presentation.

The battle of scales – Can we predict shale gas saturation logs based on petroleum systems modelling?, Martin NEUMAIER*(1), Antoine VASLIN(2), Jean-Etienne JACOLIN(2), Adrian KLEINE(2), Francesco PALCI(1), Al FRASER(1), Kate PARKIN(3), Tom WILSON (3)

(1) Imperial College London
(2) Schlumberger
(3) IGas

Basin and petroleum systems modelling is a standard industry practice in the assessment of oil and gas resources. The models are calibrated at well locations, and forward modelling predictions are made away from wells, e.g., for fluid type, column heights and average saturations. Typically, such modelling is performed at regional scale, i.e., grid cells for simulation are tens to hundreds of meters thick. All properties within one cell are considered constant, and high resolution data, e.g., coming from well logs, need to be upscaled into those cells. Therefore, the predictions are limited to the model scale.

We present a workflow where we increasingly add stratigraphic complexity to a standard 1D basin and petroleum systems model, with the goal to calibrate forward-modelled hydrocarbon saturation to well logs. The workflow has been applied to the evaluation of the Upper Bowland Shale, Gainsborough Trough, East Midlands, onshore UK. Well Scaftworth B2 has been chosen because it fully penetrates the target shale unit over 160m.

The logs available for that vintage well allowed for a quantitative evaluation are gamma-ray, neutron, density and resistivity. TOC has been determined using the Schmoker equation (1983) and calibrated to measurements from cuttings where applicable. In addition, porosity and hydrocarbon saturation have been derived. The incremental steps to complexify the 1D forward model include the subdivision into 1m high grid cells, the inversion of modelled porosity, bulk density and total organic carbon (TOC) to well logs, the inclusion of a high resolution kerogen to hydrocarbon conversion kinetic, and advanced hydrocarbon saturation calibration. Assuming a subdivision into 6 shale units, and varying TOC (within the uncertainty limits provided by the log evaluation), relative permeabilities of the stratigraphic units, critical water, oil and gas saturations as well as capillary entry pressures within some of the units allow for an acceptable manual calibration to the log-derived hydrocarbon saturation. Other derivatives of the forward model are hydrocarbon densities and condensate yields.

The resulting forward model reasonably predicts hydrocarbon saturation at the location of Scaftworth B2. The parameters from the 1D model have been propagated into a seismic-derived 3D model to predict hydrocarbon saturation at the location of well Spring Road-1, drilled in early 2019. The well has encountered large amounts of shale gas, and log acquisition, well testing and interpretation of data is ongoing. A comparison between the forward modelled pre-drill predictions and the result will be done soon.

Geomechanical characterization of unconventional formations: a key for SRV creation and production, Anton PADIN*, Hamid POURPAK, TOTAL

Commercial shale gas/oil plays are usually composed of low- to ultra-low-permeability rocks. A combination of horizontal drilling and industrial-scale stimulation techniques (hydraulic fracturing) must therefore be put in place in order to create a SRV (Stimulated Rock Volume) and achieve the economic development of such resources. Therefore, in addition to characterize the geology and reservoir related aspects of those formations, it becomes essential to characterize the geomechanical behavior of the rock to assess the fracturing capacity of the rock and predict the stimulated reservoir volume geometry and production. In this presentation, we first address the importance of taking into account geomechanics in shale development introducing fundamental factors influencing the SRV geometry. Then we present our advanced geomechanical characterization techniques including point and continuous laboratory core experiments to measure geomechanical shale properties/ characterize the SRV related parameters (e.g. rock elastic properties, rock strength, fracture toughness/brittleness index, brinell hardness, proppant embedment and fracture conductivity). We then explain how those parameters can be used to calibrate log-derived geomechanical properties/SRV parameters. Finally, we will show that this advanced geomechanical characterization approach is integrated in our unconventional multidisciplinary workflow which allows predicting the final SRV geometry and its associated production and helping us for better shale development strategy decisions.

Quantifying Water Saturation in a Source Rock Gas Play Using Multi-Frequency Dielectric Measurements, Ishan RAINA, Schlumberger MpTC

One of the challenges in exploring tight source rock plays is accurately estimating water saturation using downhole measurements. The conventional approach of using resistivity along with a saturation equation has many uncertainties, especially in the exploration setting when the treasure chest of core measurements is still lacking. Even with core data available, non-standard core handling practices often lead to misleading interpretations and incorrect calibrations.

Multi-frequency dielectric dispersion measurements provide a great way to overcome the challenges faced by the conventional resistivity based methods. These tools measure formation dielectric permittivity and conductivity at multiple frequencies. The large contrast between the permittivity of water and permittivity of rock, hydrocarbon and kerogen enables the tool to measure water volume. The dispersion observed in permittivity and conductivity with frequency is a function of the water textural parameters and salinity. Thus, this measurement does not need external textural and salinity parameters as inputs, but rather, computes these as outputs which can be used in the conventional resistivity based approach.

Multi-frequency dielectric measurements were carried out on the Diyab source rock gas play in Abu Dhabi. Comparisons to the resistivity based method led to an initial uncertainty in identifying zones of low water saturation in the source rock play, however, a core analysis program was designed to address these uncertainties. Core NMR, core dielectric permittivity, retort, total organic carbon (TOC) were among the several measurements that were carried out to characterize the formation and compute the fluid volumes in the rock. Despite the uncertainties associated with heterogeneity seen in the source rock gas play, a better match was observed between the dielectric measured water volumes and core results as compared to the resistivity based water volumes. This was due to high textural variation in the rock which was confirmed by dielectric dispersion measurements. Relative permittivity of the rock matrix was recognized as a key parameter influencing dielectric dispersion results. Core measurements were used to calibrate the calcite matrix permittivity for the Diyab formation. Limitations were recognized (and addressed) with certain core measurement sample preparation techniques which could lead to confusing results in the absence of other measurements. Core NMR was recognized as an essential measurement to quantify water volume in this study.

This is the first time that a source rock gas play has been analyzed in Abu Dhabi with such an extensive core and log program, and it is imperative that best practice methods be established to improve and add value to future interpretations. Dielectric dispersion measurement has proved to be immensely valuable in quantifying the water saturation in the source rock gas play in Abu Dhabi, overcoming several challenges we face with conventional resistivity based methods.

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Biographie des présentateurs / *About the Speakers*

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 ?, Alberto César ORTIZ, YPF

Alberto César Ortiz is a principal petrophysicist of YPF S.A. Argentina. He graduated in geology at the University de Córdoba. He started in Total Austral in 1997 and three years later he joined Schlumberger as a petrophysics based in Argentina and Brazil focused on formation evaluation using wireline and logging while drilling measurements. In 2011, he joined YPF in Buenos Aires, Argentina and since 2013 is a member of the unconventional shale play reservoir characterization team**.**

Estimating Saturations in Organic Shales Using 2D NMR, Benjamin NICOT, TOTAL

Benjamin Nicot is petrophysicist at Total E&P and involved in formation evaluation. He holds a PhD in NMR from IFP, France and worked for seven years for Schlumberger as an NMR senior research scientist, and a petrophysics domain champion. Specialized in NMR, both laboratory and log, he is also involved in formation evaluation techniques in general, and log interpretation.

Fluid typing and maturity index from logs: A new framework for petrophysical evaluation of organic-rich mudrock, Laurent MOSSE, Schlumberger

Laurent Mossé is a Principal Petrophysicist for Schlumberger Wireline. He joined Schlumberger in 2002 and first worked as a physics engineer and physics group leader on the Platform Express and the Dielectric Scanner projects, before joining the group of Petrophysics Domain Champions, first for Latin America and now for Middle East and Asia. Laurent is a graduate of Ecole Superieure d'Electricite and holds a PhD in physics from University Paris Sud.

The battle of scales – Can we predict shale gas saturation logs based on petroleum systems modelling?, Martin NEUMAIER, Consultant

Martin Neumaier received a PhD from RWTH Aachen University, Germany, where he performed structural restoration and petroleum systems modelling studies in tectonically complex areas (fold and thrust belt, salt basin). After working for 10 years as a geologist with Schlumberger, occupying various positions as a Geologist, he joined Ucon Geoconsulting in 2019. Martin is experienced in the study of sedimentary basins, in petroleum systems analysis and modeling, and in play and resource assessment. At present, he is involved in the onshore UK shale resource assessment study, a multi-year joint industry-academia project with Imperial College London. As Honorary Lecturer at Imperial, Martin supervises PhD and MSc projects and teaches basin and petroleum systems modelling at the Petroleum Geosciences MSc. Martin also contributes to various MSc modules at other universities (University of Montpellier, University of Namibia).

Geomechanical characterization of unconventional formations: a key for SRV creation and production, Anton PADIN, TOTAL

Dr. Anton Padin is a geoscientist and rock physicist working at "Unconventional Product Line" at Total E&P in Pau, France. He holds a PhD in Petroleum Engineering from Colorado School of Mines, a MsC in Engineering from Heriot-Watt University and a BsC in Geology from the University of Madrid. Prior to working for Total, Anton has worked in reservoir geomechanics, petrophysics and geology positions in deepwater and unconventional fields for Shell USA, Endesa CO_2-CCS and Cepsa E&P.

Quantifying Water Saturation in a Source Rock Gas Play Using Multi-Frequency Dielectric Measurements, Ishan RAINA, Schlumberger MpTC

Ishan Raina is a Senior Petrophysicist with Schlumberger, with 10 years of experience in the industry during which he has worked in a variety of roles including Operations Petrophysicist, Studies Petrophysicist and Core Analyst, working in carbonate and source rock play environments. Ishan is currently based in France, leading the development of next generation wellbore interpretation workflows on cloud.