SOCIETY OF PETROPHYSICISTS AND WELL LOG ANALYSTS
SAUDI ARABIA CHAPTER

10th SPWLA Saudi Arabia Chapter Online Topical Workshop
October/November 2021

SPWLA Saudi Arabia Chapter (SAC)

DATA DRIVEN PETROPHYSICS – Challenges and Best Practices

Digital Transformation, what is it? Machine Learning (ML) and Artificial Intelligence (AI), how do they work and impact us, the petrophysicists? Those topics are what everyone keeps talking about nowadays, in our industry and around the globe. But do we really know what they mean? And how they will be used and impact the future of upstream business in general and petrophysics in particular? This online workshop is developed to answer some, surely nor all, of these questions. It will open with a session introducing the fundamentals of data analytics and ML/AI where experts in the field will share their knowledge and experiences. The following sessions will explore the applications of data driven petrophysics in the subject matters of formation evaluation, geosteering, dynamic reservoir surveillance, laboratory core and fluid analyses, and unconventional resources evaluations. Since we are merely at the very beginning of this digital transformation, a session dedicated to emerging technologies in data driven petrophysics will conclude this topical workshop.

Opening & Keynote Speeches by:

Mr. Khalid Zainalabedin
Manager - Reservoir Description and Simulation Department
Saudi Aramco

Dr. Dhafer Al-Shehri
Chairman of Petroleum Engineering Department
KFUPM

Mr. Ziad Jeha
KSA and Bahrain Managing Director
Schlumberger

Dr. Ridvan Akkurt
AI &Analytics Petrophysics Advisor
Schlumberger

	Date	Time	Subject
1	29-Sep-21	12:00-15:00	**Fundamentals of data analytics and machine learning**
2	06-Oct-21	12:00-15:00	**Data driven petrophysics- Data Preparation and Quality Control**
3	13-Oct-21	12:00-15:00	**Data driven petrophysics- Applications in borehole imaging and geo-steering**
4	20-Oct-21	12:00-15:00	**Data driven petrophysics- Applications in Rock Typing and Formation Evaluation**
5	27-Oct-21	12:00-15:00	**Data driven petrophysics- Applications in Reservoir Evaluation**
6	03-Nov-21	12:00-15:00	**Data driven petrophysics- Applications in Formation Testing and Sampling**
7	10-Nov-21	12:00-15:00	**Data Driven Petrophysics- Applications in Unconventional Source Rock Evaluation**

Workshop Target Audience:

- Petrophysicists as well as logging and log analysists
- Reservoir engineers and simulation engineers
- Geophysicists, Geologists, and Geo-Modellers
- Rock/geo-mechanical Subject Matter Experts
- Drilling and Production engineers
- Upstream Researchers

This event is sponsored by: Schlumberger

Registration

www.spwla-saudi.org

info@spwla-saudi.org

Maximum attendees 250 in each session

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SPWLA (SAC) Data Driven Petrophysics Workshop Program

Session 7 Agenda

Session 7 Technical Session - Applications in Unconventional Source Rock Evaluation

Wael Abdallah (Schlumberger) /Tammam Ashrafi (Baker Hughes)

Wednesday, 10 November 2021

12:00-12:10	**Session opening (all times are KSA times GMT+3)**		
12:10-12:45	Shale Brittleness Prediction using Machine Learning – A Middle East Basin Case Study	Ayyaz Mustafa	KFUPM
12:45-13:20	An unsupervised learning algorithm to compute fluid volumes from NMR T1-T2 logs in unconventional reservoirs	Lalitha Venkata-ramanan	Schlumberger
13:20-13:55	Advanced Mineral Quantification and Uncertainty Analysis from Wellbore Spectroscopy via Machine Learning	Paul Craddock	Schlumberger
13:55-14:15	**Session 7 Summary and closing remarks**	**Mark Ma**	**Saudi Aramco**

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Shale Brittleness Prediction using Machine Learning – A Middle East Basin Case Study

Ayyaz Mustafa, Zeeshan Tariq, Mohamed Mahmoud, Abdulazeez Abdulraheem, KFUPM

Abstract

Brittleness Index (BI) of rocks can help target the most suitable formation for the hydraulic fracturing stimulation in the shale reservoirs. The two most widely used approaches in the petroleum industry are based on mineralogical composition and elastic parameters for the BI estimation. However, these approaches may not be applied for all wells for BI determination due to the scarcity of mineralogical-composition and shear wave slowness data. This paper presents a Machine Learning approach to predict the BI using readily available well logs. Well log data were collected from three different wells that encompass a total of 2000 ft thick interval of potential shale gas formation in one of the middle eastern basins in the south-eastern part of Saudi Arabia. Mineralogical composition of shale formation revealed that the shale intervals were comprising of alternate high brittle and low brittle layers/zones and mainly composed of quartz, clay, feldspar, and mica. Feed-forward artificial neural network (FFANN) and Adaptive Neuro-Fuzzy Inference System (ANFIS) were employed to develop the predictive model for the BI using conventional well logs. The proposed model was tested and validated to check the consistency of the model. A total of 2007 data points were utilized in this study. ANN was found to be better than ANFIS by giving high accuracy. The proposed model was then compared with widely used models in the industry such as Jarvie et al., (2007) and Rybacki et al., (2016) on a blind dataset. Results showed that the proposed model outperformed previous models by giving less error.

Biography

Ayyaz Mustafa has been working as a Researcher/Engineer-II at the Centre for Integrative Petroleum Research, College of Petroleum Engineering and Geosciences, King Fahd University of Petroleum and Minerals (KFUPM), Dhahran, Saudi Arabia since March 2018. He is a part of Geomechanics, Petrophysics and Geophysics Research Group. He holds Master's degree in Geosciences from KFUPM. His research focus is on geomechanics, rock physics, artificial intelligence, and enhanced oil recovery in tight reservoirs. He has published over 15 scientific papers in reputed journals and conferences.

An unsupervised learning algorithm to compute fluid volumes from NMR T1-T2 logs in unconventional reservoirs

Lalitha Venkataramanan, David Allen, Albina Mutina and Andrew C. Johnson, Schlumberger

Abstract

T1-T2 maps from wireline NMR logging tools show unique signatures for hydrocarbons such as bitumen and producible and bound oil and gas. Similarly, capillary and clay-bound water and water in larger pores have different signatures. However, these signatures depend not only on the fluid and the pore geometry but also the geometrical configuration of oil and water phases within the pore space. Where the formation is homogenous, variation in T1-T2 maps at the different depths is due to variation in fluid volumes. These volumes are usually calculated by using predetermined cutoff values otained from analysis of laboratory data in the T1-T2 domain. However, these cutoff values are lithology dependent and also a function of the unknown fluid properties. Thus, is desirable to have an automated algorithm that can compute fluid volumes from T1-T2 maps. In this paper, we describe an u supervised learning algorithm to estimate the footprint of the different fluids in T1-T2 maps and subsequently compute their fluid volumes. Leveraging our knowledge of the physics of the relaxation processes and measurements of laboratory datasets, we propose a hierarchical clustering method consisting of the following steps. First, we use the signal to noise ratio in the data to obtain a rough estimate of the overall footprint of all the fluids. Second, assuming each point in T1-T2 space corresponds at most to one fluid, a non-negative matrix factorization technique is used to compute a footprint corresponding to the different fluids. A hierarchical clustering method is used to ensure that the footprint of each fluid is compact and connected in the T1-T2 domain. Subsampling of the maps is used to study the stability and compute the most likely number of fluids present. The final step consists of applying the mask corresponding to the different fluids to the measured T1-T2 maps to determine the fluid volumes. There are a few key advantages of this method over other methods proposed in the literature. First, it does not require predetermined information about cutoffs to distinguish fluids. The cutoffs are automatically estimated from the data. Second, simulations show that the method does not require a wide variation in fluid volumes at different depths. This allows the petrophysicist to pick a relatively short depth interval consisting of one rock type to study measurement variation due to variations in fluid properties. Last, it provides a framework to automatically compute the number of fluids in the underlying dataset. We demonstrate the application of this method on simulated datasets.

Biography

Lalitha Venkataramanan is the Reservoir Performance - Data Science Advisor at Schlumberger. She is also a Scientific Advisor and the Associate Editor for NMR Petrophysics. She is the recipient of the SPWLA distinguished technical award in 2021. She is on the board of SIAM and NSERC as well as Business-Industry Government Math network. Her current interests include machine learning, mathematical modeling and inversion, optimization, probability and stochastic processes. Trained as an Electrical Engineer, she obtained her M.S and PhD degrees from Yale University in 1998. She has co-authored more than 40+ peer reviewed publications and has over 24 granted US patents and 18 pending patent applications.

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Advanced mineral quantification and uncertainty analysis from wellbore spectroscopy via machine learning

Paul R. Craddock, Prakhar Srivastava, Harish Datir, David Rose, Tong Zhou, Laurent Mosse, Lalitha Venkataramanan, Schlumberger

Abstract

We present here an innovative machine learning model, based on variational autoencoder frameworks, to infer concentrations and associated uncertainties of common minerals in sedimentary formations using the measurement of atomic element concentrations from geochemical spectroscopy logs.

The framework comprises an input(s), encoder mapping function, decoder mapping function, output(s), and a novel cost function to optimize the mapping functions coefficients during training of the model. The input to the model is a set of 9 dry-weight elemental concentrations. The outputs from the model are sets of 14 dry-weight mineral concentrations (with uncertainties) and 9 dry-weight elemental reconstructions (with uncertainties); the latter is useful as a quality control on the mineralogy solution. The encoder and decoder are multilayer feed-forward artificial neural networks (ANN). The cost function simultaneously minimizes error (the accuracy metric) and variance (the precision or robustness metric) on the outputs. Training of the model is done using a set of several-thousand core samples with independent, high-fidelity elemental and mineral data.

Our approach provides several advantages over existing methods to estimate formation lithology or mineralogy. The ANN mapping functions numerically capture the multi-dimensional and nonlinear geochemical relationship between elements and minerals that is insufficiently described by prior linear regression methods. Training is iterative and samples from Gaussian distributions on each of the elemental inputs, rather than single values, at each iteration. These Gaussian distributions are chosen to specifically represent the unique statistical uncertainty of the dry-weight elements in logging measurements. Sampling from Gaussian distributions during training reduces potential for overfitting, provides robustness for log interpretations, and enables a calibrated estimate of uncertainty on the mineral and reconstructed elemental outputs, which are lacking in prior methods. The framework enables models to be optimized for multiple types and generations of spectroscopy tools by accounting for tool-specific uncertainties during model training. The framework is adaptable to different architectures, specifically to the number and type of elements (inputs) and minerals (outputs). The model reasonably approximates a 'global-average' that requires no expert parameterization or intervention for interpreting common oilfield sedimentary formations. Nonetheless, the framework further permits local optimization of the global-average model where desirable. The result is an advanced and extensible framework for estimation formation properties from wellbore spectroscopy measurements.

Biography

Paul Craddock is a Senior Research Scientist in the Modeling & Interpretation Department at Schlumberger-Doll Research Center (SDR) in Cambridge, Mass. His research addresses oilfield formation evaluation using nuclear, X-ray, infrared spectroscopy, and most recently machine learning methods. He has developed methods to: derive resistivity-independent saturation from spectroscopy logs; indicate zones for favorable well placement and production in shale (Reservoir Producibility Index, RPI); combine cuttings and logs for enhanced petrophysics in data-poor shale wells; and optimize kerogen properties for global shale evaluation (Thermal Maturity-Adjusted Log Interpretation, TMALI). He received a Ph.D. in chemical oceanography from Massachusetts Institute of Technology/Woods Hole Oceanographic Institution. Paul has served as a Distinguished Lecturer for SPE (2016-17 and 2019-20) and is (2020-21) and a Distinguished Speaker for SPWLA an active member of both organizations.

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