London Petrophysical Society

AI & ML in Petrophysics - Friend or Foe?

Virtual Seminar

Thursday 16th September 2021

Abstracts

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Agenda

		London Petrophysical Society - - September 16th - AI & ML in Petrophysics - Friend or Foe?		
Start Time	End Time	Name	Company	Talk Title
09:00	09:10	Jack Willis	LPS - VP Sponsorship	LPS VP Sponsorship - Welcome and Introduction
09:10	09:35	Andy Mc Donald	Lloyd's Register	Machine Learning and Its Applications to Petrophysics
09:35	10:00	Heloise Beurdouche	Schlumberger	Orchestrate wellbore data conditioning & interpretation through artificial intelligence
10:00	10:25	Rebecca Nye	Enovate Upstream	Cloud-based Automation Methods for Formation Evaluation Optimization, Risk Mitigation and Decarbonization
10:25	10:45	Comfort Break		
10:45	11:10	Ibrahim Milad	BP	Machine learning to predict large pores and permeability in carbonate reservoir using standard logs
11:10	11:35	Waclaw (Wally) Jakubowicz	Hampton Data Services Ltd	Automating Well Data Validation and QC before running AI and ML analytics
11:35	12:00	Steve Cuddy	Petro Innovations	Machine Learning in Petrophysics: 5 Challenging Case Studies
12:00	13:00	Lunch		
13:00	13:25	Lalitha Venkataramanan	SDR	Uncertainty quantification using machine learning in petrophysics
13:25	13:50	Allen W. Britton	Core Laboratories	An Artificial Intelligence Approach to Finding Core-Based Petrophysical Analogs
13:50	14:15	Chafaa Badis & Welton Souza	Halliburton	Analysing downhole conditions by applying machine learning to cuttings video images
14:15	14:40	Cameron Snow	Danomics	AI/ML for Property Prediction from Well Logs Lessons Learned
14:40	14:45	Ian Draper	LPS - President	Closing remarks

09.10 – 09.35: Machine Learning and Its Applications to Petrophysics, **Andy McDonald, Lloyds Register**

Over the past couple of decades, the interest and research in Artificial Intelligence and Machine Learning have increased significantly. This increase is also reflected within the geoscience and petrophysics disciplines. Machine Learning can be used to speed up several areas within petrophysical workflows, such as data quality control and depth matching, thereby reducing tedious input and increasing time spent on more advanced analytics. Many view these new algorithms as something that can replace a human petrophysicist. Instead, they should be viewed as an additional tool within our petrophysical toolbox that enables us to better understand our data. This can lead to making more effective interpretations and thereby more informed decisions.

Within this presentation, the basics of what machine learning is and examples of how it is currently being applied to petrophysical workflows and data will be discussed. These examples include assisting in quality checking well log measurements, carrying out automated data repair, predicting missing data, reservoir rock typing and reservoir characterisation.

Andy McDonald is a Petrophysicist with Lloyd's Register in Aberdeen and has over 15 years of industry experience. He currently provides petrophysical expertise to software development projects and specialises in Python development, artificial intelligence and applications of machine learning to petrophysics. He has been selected as a distinguished speaker for SPWLA for 2021 – 2022. Andy holds an MSc in Earth Science from the Open University, and a BSc (Hons) in Geology & Petroleum Geology from the University of Aberdeen. He has also co-authored several technical conference papers for the SPWLA and SPE on topics covering machine learning, heavy oil, geomechanics and low salinity waterflooding.

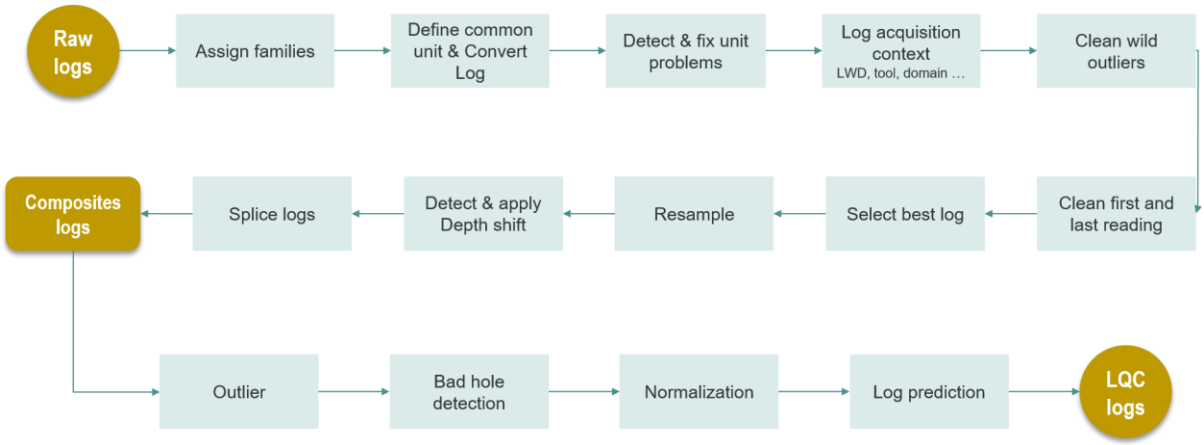
09.35 – 10.00 : **Orchestrate wellbore data conditioning & interpretation through artificial intelligence, Heloise Beurdouche, Schlumberger**

The first ever well-log was recorded by Schlumberger, in 1927, 93 years ago, and since then a large

number and variety of well-logs have been acquired, processed, and stored. These logs are used to characterize various properties of rocks and fluids in a formation. As petrophysics and more generally geoscientists want to make the best usage of well logs (legacy and new), they still have to devote an important part of their time finding, sanitizing, and cleaning well data, as these steps today are still overall manual. Furthermore, these tasks run in detriment of pure interpretation process.

In order to significantly decrease the time spent by experts in these steps, the approach we present consist in automating and assisting experts in these data preparation steps. Their new role is more to review the results from automated workflows, with the input of the uncertainty that is provided for quality control throughout the process. Algorithms fit for log conditioning and interpretation workflows have been developed using artificial intelligence (AI) and machine learning (ML). A big data framework was developed to handle large amount of logs data, enabling the AI algorithms to run at scale.

To sum up the new algorithms targets mandatory and mundane steps, deliver clean data together with the associated uncertainty, for final expert validation.



Heloise Beurdouche is Digital Wellbore Product Analyst at Schlumberger. She joined Schlumberger in 2012 in the Techlog and Studio software testing and support team. After a team lead experience, she moved to software development for Delfi log conditioning and interpretation applications. She experiences new ways to condition logs using data science and machine learning. She holds a MSc in Geology (ENSG, Nancy, France) and in Geophysics (EOST, Strasbourg, France).

10:00 – 10.25 : **Cloud-based Automation Methods for Formation Evaluation Optimization, Risk Mitigation and Decarbonization, Rebecca Nye, Enovate Upstream**

Recent developments in artificial intelligence (AI) have enabled upstream exploration and production companies to make better, faster and accurate decisions at any stage of well construction, while reducing operational expenditure and risk, increasing logistic efficiencies. The achieved optimization through digitization at the wellsite will significantly reduce the carbon emissions per well drilled when fully embraced by the industry. In addition, an industry pushed to drill in more challenging environments, they must embrace safer and more practical methods.

An increase in prediction techniques, to generate formation evaluation wellbore logs, has unlocked the ability to implement a combination of predictive and prescriptive analytics with petrophysical and geochemical workflows in real time. The foundation of the real time automation is based on advanced machine learning (ML) techniques that are deployed via cloud connectivity.

Three levels of logging precision are defined in the automated workflow based on the data inputs and machine learning models. The first level is the forecasting ahead of the bit that implements advanced machine learning using historical data, aiding proactive operational decisions. The second level has improved precision by incorporating real time drilling measurements and providing a credible contingency to for wellbore logging program. The last level incorporates petrophysical workflows and geochemical measurements to achieve the highest precision for logging prediction in the industry. Supervised and unsupervised machine learning models are presented to demonstrate the path for automation.

Precision above 95% in the real time automated workflows was achieved with a combination of physics and advanced machine learning models. The automation of the workflow has assisted with optimization of logging programs utilizing technology with costly lost in hole charges and high rate of tool failures in offshore operations.

The optimization has reduced the requirement for logistics associated with logging and eliminated the need for radioactive sources and lithium batteries. Highest precision in logging prediction has been achieved through an automated workflow for real time operations.

Rebecca Nye is a science-driven strategist who has worked in the upstream oil and gas international business for the past 15 years for services companies like Weatherford International and Schlumberger, where she worked in varies operational, technical and management roles. She has extensive experience in the drilling and evaluation field, in particular the development and implementation of downhole logging technologies.

Rebecca is the Chief Experience Officer for Enovate Upstream, she is responsible for the continuous improvement of the customer's overall experience. She is an action-driven leader for business development, digital visualization and achieving the goals for Environment, Social and Governance. She is deeply involved in efforts to increase overall sustainability for the O&G industry focusing on accelerating the adoption of AI services at the wellsite, which decreases the carbon footprint and is vital to meeting the sustainability goals for the industry.

10:45 – 11.10 : **Machine learning to predict large pores and permeability in carbonate reservoir using standard logs, Ibrahim Milad, BP**

A study was conducted on more than 1000 wells across the Mishrif carbonate reservoir in the Rumaila field, located in South East Iraq, one of the giant reservoirs in the world. Whilst Rumaila has been producing for more than 50 years, there are billions of barrels yet to be recovered and Mishrif is anticipated to play a significant role in supporting field production for decades. Reservoir pressure has dropped due to historical production and large-scale water injection is being implemented to support and enhance future production rates and oil recovery.

One of the key subsurface challenges is to understand and characterise reservoir complexity and heterogeneity, with permeability being one of the key factors in understanding sweep behavior and predicting production and injection rates. Rumaila has extensive surveillance programs and production and saturation logs are used to refine static and dynamic models and to better characterise individual well performance. With more than 1,000 well penetrations to date, efficient management of wells is key to optim¬¬ising production.

In 2020, a workflow was introduced (Ibrahim. B. Milad et. al., 2020) that utilised NMR logs, NMR core analysis and FZI techniques to predict large pores and permeability. The approach distinguished different pore types by estimating the relative proportion of large pores (Large Pores Index - LPI) from NMR data and using this as an input to prediction of FZI rock types and subsequently prediction of permeability. Results showed a significant improvement compared to more traditional approaches but could only be applied in modern wells with NMR data.

The work presented in this paper extends this study to wells with no NMR by using machine learning techniques, linear regression and python coding to predict changes in pore sizes and estimate the relative proportion of large pores in wells without NMR. The resulting Large Pores Index from Machine Learning (LPI_ML) was applied on more than 1000 wells to generate rock types and permeability estimates that demonstrate a significant improvement when compared with core data.

This improvement is reflected in better predictions of production and injection indexes, improved understanding of sweep behaviour and timing for water breakthrough across the field, leading to more optimal management of reservoir performance. Moreover, at a well level the new permeability model has resulted in enhanced completion decisions for well-work operations (additional perforation and re-perforation campaigns) on existing producers and injectors, generating significant value for the stakeholders and Iraq.

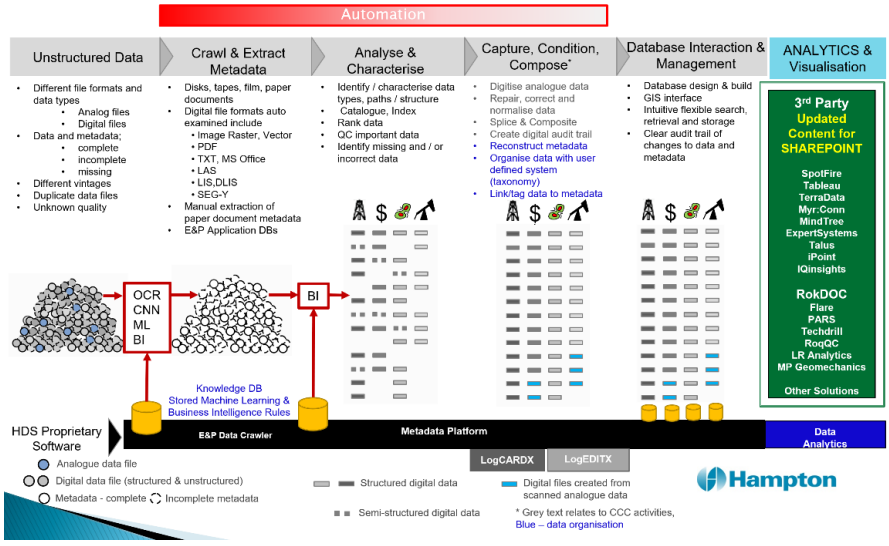
Ibrahim B. Milad has 22 years of industry experience, he is currently a Senior Petrophysicist in BP. He studied Geology at Benghazi University 1998 and MSc.Geoscience at Herriot Watt University (2007). He worked as Geologist and Petrophysicist with Sirte Oil Company-Libya for 9 years. He then joined BP in 2009 and worked as Petrophysicist in a Libya exploration project, Access, and exploration (Australia, Spain and Iraq) and the Rumaila-Iraq project in several roles since 2012. Ibrahim is currently working for bp's global subsurface solutions team focusing on Middle East and Iraq. He is based in London. He has been selected as global distinguished speaker for SPWLA 2021-22.

11.10 – 11.35 : **Automating Well Data Validation and QC before running AI and ML analytics, Waclaw (Wally) Jakubowicz, Hampton Data Services Ltd**

Running AI and ML on data of unknown provenance and quality potentially creates more bad data with larger uncertainty. Data must be verified prior to being used in any serious formation evaluation or for analytics. Taking one's cue from Harvey Smith, the legendary Yorkshire show jumper, the issues with data QC comes down to the "4 Vs", namely volume, variety, velocity, and validation.

The quantity of data that the oil & gas sector must cope with continues to grow exponentially, coming in an increasing assortment of formats, and at an ever-faster pace. Hence, the active corporate data servers where these data reside have become semi-structured or unstructured, with limited metadata catalogues, so that traditional manual data discovery and comprehensive validation are no longer possible. These issues are compounded by the decreasing number of experienced technical staff available in the E&P industry such that data validation and QC are rarely done.

This presentation looks at methodologies and well data workflows that utilise business intelligence, ML, and possibly AI, to automate and accelerate data confirmation and clean-up, prior to their use as inputs to more advanced interpretation and analytics.



Wally Jakubowicz (BSc Geol MSc Geophys DIC) has spent over four decades in the oil and gas industry. After working for Schlumberger as a wireline engineer, geophysicist and petrophysicist, he went on to be an independent consultant for many clients around the world. In parallel to his geoscience career, Wally has spent the last 30 years in subsurface data and information management. This was largely driven out of the frustration of having to constantly initiate studies with poor quality, incomplete, and unauthenticated data and then struggling to find the necessary supporting critical data needed for an optimal interpretation.

Wally founded Hampton Data Services which offers its own efficient E&P data discovery applications and clean up workflows. These bespoke methodologies use ML, BI rules, and neural networks to create an Automated Virtual Data Management environment to index, classify and spatially link large volumes of unstructured data that are "swimming or submerged in data seas".

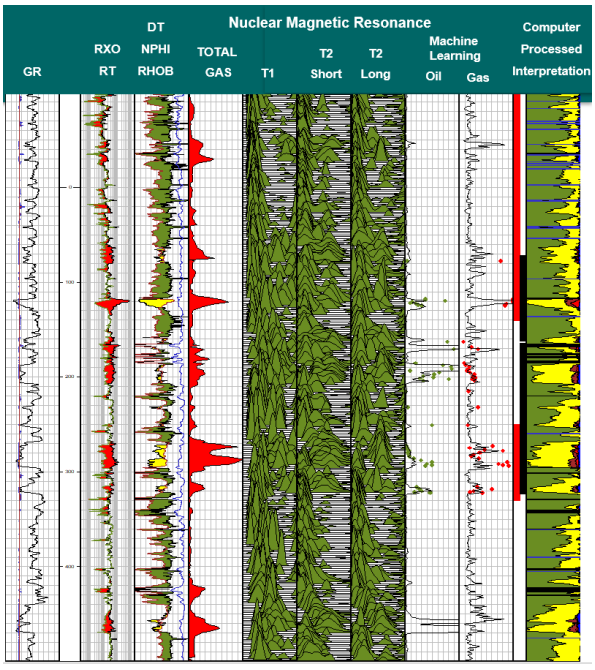
11.35 – 12.00 : **Machine Learning in Petrophysics: 5 Challenging Case Studies, Steve Cuddy, Petro Innovations**

Machine Learning, or ML, is a method of data analysis that learns from data, identify patterns and makes predictions with the minimal human intervention. ML is bringing many benefits to petrophysical evaluation. Using case studies, this presentation describes five successful applications.

A complex Middle East Carbonate field needed a bespoke shaly water saturation equation. ML was used to 'evolve' an ideal equation, together with field specific saturation and cementation exponents. One gas field, on the UK continental shelf, had an 'oil problem'. Here, ML was used to unlock the hidden fluid information in the NMR T1 and T2 spectra and successfully differentiate oil and gas zones in real time. A North Sea field with 30 wells had shear velocity data (Vs) in only 4 wells. Vs was required for reservoir modelling and well bore stability prediction. ML was used to predict Vs in all 30 wells. Incorporating high vertical resolution data, the Vs predictions were even better than the recorded logs.

As it is not economic to take core data on every well, ML is used to discover the relationships between logs, core, litho-facies and permeability in multi-dimensional data space. As a consequence, all wells in a field were populated with these data to build a robust reservoir model. In addition, the ML predicted data upscaled correctly unlike many conventional techniques. ML gives impressive results when automatically log quality controlling (LQC) and repairing electrical logs for bad hole and sections of missing data.

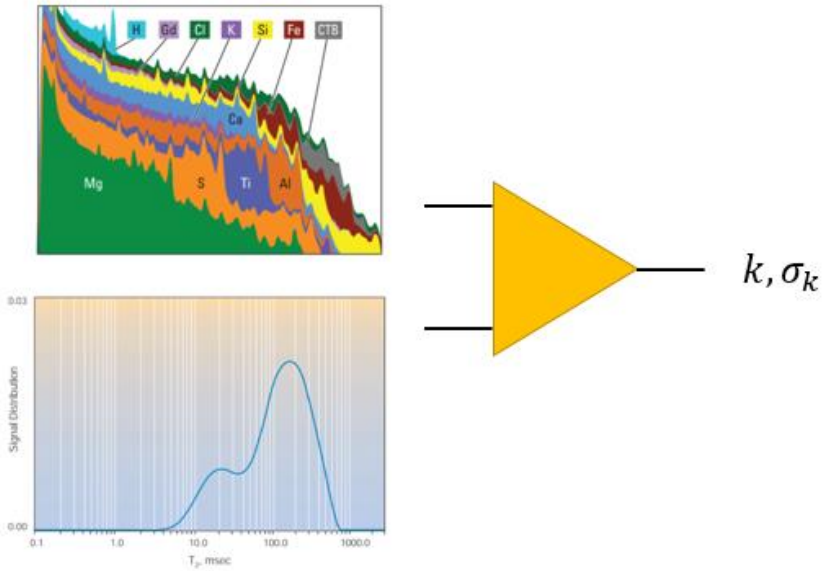
ML doesn't require prior knowledge of the petrophysical response equations and is self-calibrating. There are no parameters to pick or cross-plots to make. There is very little user intervention and ML avoids the problem of 'garbage in, garbage out, by ignoring noise and outliers. ML programs work with an unlimited number of electrical logs, core and gas chromatography data; and don't 'fall-over' if some of these inputs are missing.



Steve Cuddy holds a PhD in petrophysics from Aberdeen University. He also holds a BSc in physics and a BSc in astrophysics and philosophy. He writes ML software and has 45 years industry experience in petrophysics working with Schlumberger, BP and Baker Hughes. In recognition of outstanding service to the SPWLA, Steve was awarded the Distinguished Service Award in 2018.

13.00 – 13.25 : **Uncertainty quantification using machine learning in petrophysics, Lalitha Venkataramanan, SDR**

In the past few years, machine learning (ML) algorithms are being used to estimate the rock and fluid properties from the measured downhole data. These algorithms have been shown to be extremely effective for various classification and regression problems, but quantifying the uncertainty of their predictions continues to be a challenging task. Understanding the sources of the uncertainties, quantifying and reducing them is key to designing intelligent tools and applications such as automated log interpretation answer products for exploration and field development. In this presentation, I will discuss the various methods of estimating uncertainties including dropouts, Bayesian neural networks, dual neural networks, their calibration as well as interpretability of machine learning algorithms.

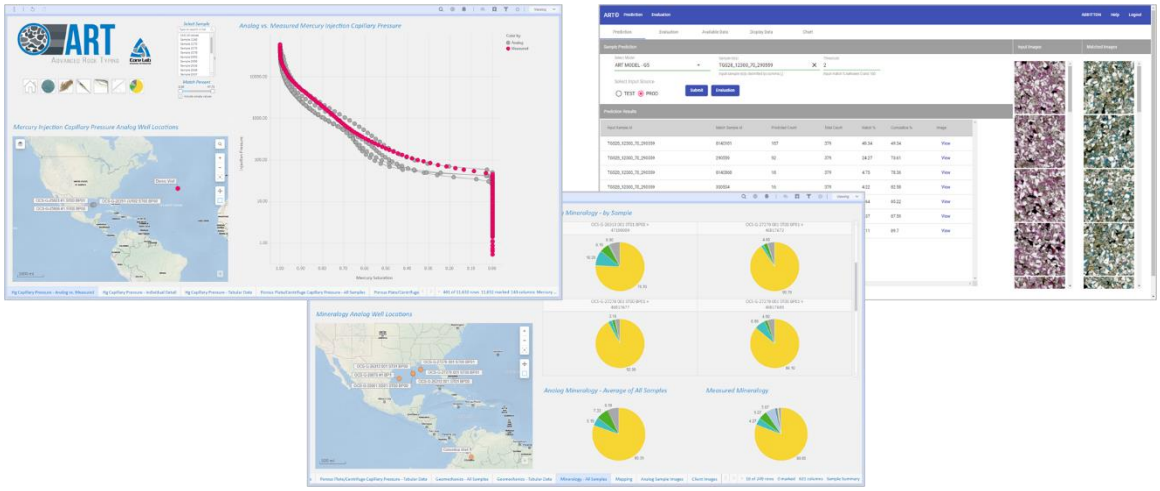


Lalitha Venkataramanan is the Reservoir Performance - Data Science Advisor at Schlumberger. She is also a Scientific Advisor and the Associate Editor for NMR-Petrophysics. She is the recipient of the SPWLA distinguished technical award in 2021. She is on the board of SIAM and NSERC as well as Business-Industry-Government 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.

13.25 – 13.50 : **An Artificial Intelligence Approach to Finding Core-Based Petrophysical Analogs, Allen W. Britton, Core Laboratories**

The need for petrophysical data used in reservoir characterization studies continues to grow despite virtually every oil and gas operator currently stressing the need for cost reductions. Geologic and engineering teams are being told that they must do without when it comes to recovering conventional core, long the gold standard for petrophysical data, and in some cases even the recovery of sidewall core samples is being severely constrained. Making do with less has become the new normal.

To address this new reality, Core Laboratories has developed a solution called Advanced Rock Typing (ART). Relying on formation representative high-resolution thin section images of >2mm cuttings, micro core samples and/or sidewall core samples as an input, ART utilizes an artificial intelligence (AI) model to find physically measured analog petrophysical data in Core Lab's petrophysical database, RAPIDTM. We find, rank, and return analog data sets that include physically measured porosity, permeability, capillary pressure, electrical properties, geomechanical properties, NMR data as well as mineralogy and petrographic parameters. The rigorously validated ART model evaluates the heterogeneity inherent in each submitted thin section and returns probability-based analog matches that represent the range of that heterogeneity. Results are presented in an interactive web-based application which allows the user to explore the results and export data to third party analytical applications used in their existing workflows. The ART model includes clastic and carbonate rock types from throughout the world and is continuously being expanded with additional rock types.



Allen Britton, is responsible for International Business Development of Core Laboratories' Digital Innovation Group. He has over 40 years of experience at Core Laboratories in a wide variety of positions. His current responsibilities include development of AI technologies (Advanced Rock Typing), marketing of Joint Industry Projects as well as Data Management services (RAPID database, Relative Permeability Toolkit and RAPID Analytics). Formerly, he was the Manager of Core Laboratories' Coastal Regions, which included the U.S. West Coast and Gulf Coast Petroleum Services operations. For over 25 years he has been a guest lecturer at Stanford University on petrophysical applications to log analysis in reservoir evaluation. He is a member of AAPG (Past-President and Honorary Lifetime Member of the Pacific Section AAPG).

13.50 – 14.15 : **Analysing downhole conditions by applying machine learning to cuttings video images, Chafaa Badis & Welton Souza, Halliburton**

The appearance of formation cuttings such as shape and size passing over shaker screens can provide valuable insights into downhole problems. Large cuttings or cavings may indicate presence of an abnormal pressure zone and hole size may be enlarged, which may lead to HSE incidents, asset loss or non-productive time (NPT) events such as stuck pipe or lost circulation. We proposed a new method of real-time automated analysis of cuttings in the shale shaker enabling faster reaction to mitigate risks associated with drilling operations. The solution used a camera on the shaker screen, capturing the cuttings images and applying computer vision and convolutional neural networks algorithms to identify and classify individual cuttings shape, size and type combined with wireline data to raise alarms on specific conditions and prescribe actions to mitigate the problem. The solution showed a very high confidence in identifying the cuttings types and size and in detecting possible problems at an early stage, enabling the drilling engineers to take the corrective actions as soon as an event starts occurring.

Chafaa Badis is the Lead Data Scientist for E&P industry in Eurasia, Europe and Sub-Saharan Africa Region at Halliburton Landmark. He has created innovative AI solutions based on machine learning, computer vision, NLP and deep learning techniques for drilling automation and optimization, predictive maintenance, and borehole data management automation. His work resulted in 6 US patent applications. Mr. Badis has an engineer's degree in Computer Science & Artificial intelligence from the University of Science and Technology – Houari Boumediene in Algiers and a Master's degree in Business Intelligence & Data science from the University of Toulouse (France).

Welton Souza is an Industry Solution Advisor working closely with E&P companies in Eurasia, Europe and Sub-Saharan Africa in their digital transformation journey with 16 years industry experience. During this time, he has been involved in managing high performance teams, end-to-end integrated workflows, cloud and data science solutions. Welton has a Bachelor's Degree in Computer Engineering from the Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio).

14.15 – 14:40 : **AI/ML for Property Prediction from Well Logs Lessons Learned, Cameron Snow, Danomics**

Machine learning models have the potential to accelerate, enhance, and revolutionize petrophysical workflows. AI/ML techniques have the potential to increase the accuracy and consistency of interpretations, reduce interpretation turn-around times, enhance the decision-making process, and reduce capital spending.

However, the path to the promised land of an AI/ML future can be perilous and there are numerous potential pitfalls along the way. Failure to fully understand the consequences of how data is treated before the model-building begins and the levels of confidence can set the stage for overconfidence in models and frustration post-deployment.

AI/ML models can have different scopes with respect to how they are deployed. These can broadly be split into “small” and “big” AI/ML models. Small applications are ones that affect isolated steps within the petrophysical workflow while big applications are used to generate actionable insights, potentially eliminating some or all of the intermediate interpretative steps.

Although AI/ML models may lead to better, more repeatable results that can be generated in shorter timeframes their development and deployment is not without risk. Companies seeking to deploy models must consider the economics of AI/ML solutions and individual users must use caution to ensure that they maintain proper oversight of their interpretations.

Cameron Snow is a petrophysicist and geoscientist with 20 years of experience in the oil and gas industry. He has worked across the subsurface life-cycle from early-stage exploration and new ventures to field development projects. His geographical experience includes onshore North America, the Gulf of Mexico, South America, Africa, and Australia. Cameron has held senior management roles at Apache, SDX Energy, and Wentworth Resources. Cameron co-founded Danomics.com, a Petrophysics and Geoscience platform where he is responsible for providing direct oversight for developing the subsurface evaluation workflows and their integration into the platform. He holds a BSc, MSc, and PhD in Geology as well as an MBA