SPWLA SAC 12th Topical Workshop

Saudi Arabia Chapter

SPWLA SAC 12th Topical Workshop
Shaly Formation Petrophysics and Thin-bed Analysis

Date: 8th of February 2023, 08:00 to 15:30 - **Venue**: Al Maha Hall- Kempinski Hotel Al Khobar, Saudi Arabia

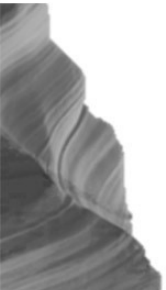
Workshop Objective

Shaly formations and/or thin-bed reservoirs, why are they so challenging to evaluate? For shaly rocks, the presence of clay minerals (their type, amount, and distribution) strongly affects the formation petrophysical properties, causing difficulties in their measurements and interpretation; in the laboratory as well as with downhole logs. As for thin-beds reservoirs; those with bed thickness less than the vertical resolution of conventional logs, such as the typical 2 feet of the triple or quad combo logs, although they may be characterized properly if high resolution logs such as borehole imaging and NMR are available and formation evaluation logs are properly modeled thus petrophysical properties of each thin-bed can be extracted, but that is not routinely done mainly due to lacking of proper measurements and/or modeling capabilities. The main objectives of this topical workshop are to tackle those technical challenges in evaluating shaly formations and thin-bed reservoirs, from data acquisition, data processing and modeling, data interpretation and integration to arrive in best-in-class characterization of shaly formations and thin-bed reservoirs.

This event sponsored by

HALLIBURTON

Registration though **Eventbrite**
Limited seats to 100



Keynote Speaker

Saudi Arabia Chapter

Mr. Khalid Zainalabedin

Manager

Reservoir Description and Simulation Department

Workshop Program

Date: 8th of February 2023, 08:00 to 15:30 - **Venue:** Al Maha Hall- Kempinski Hotel Al Khobar, Saudi Arabia

Saudi Arabia Chapter

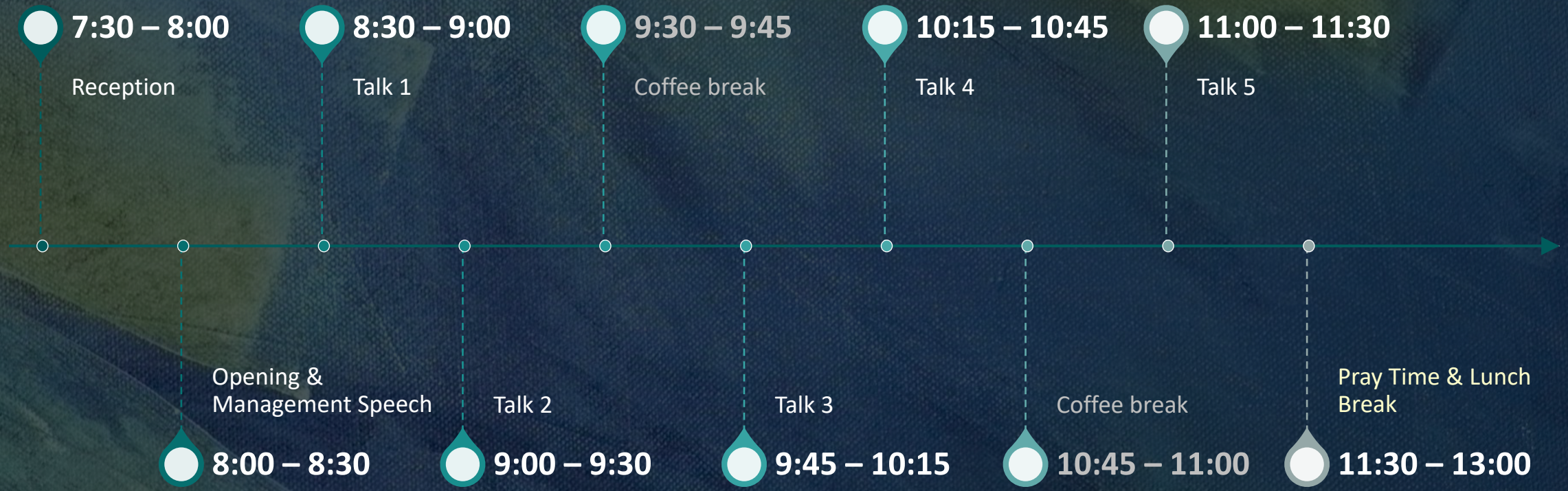
Time	Activity
07:30 – 08:00	Reception
08:00 – 08:30	Opening, Keynote Speech

Session chairpersons *Mohammad Aljishi / Ahoud AlKhaldi*

Time	Talk	Speaker	Company
08:30 – 09:00	MINIMIZING UNCERTAINTIES IN LAMINATED SHALY SAND USING ADVANCED PETROPHYSICAL TECHNOLOGIES IN INTEGRATED WORKFLOW - A CASE STUDY	**Ehab Najm**	Halliburton
09:00 – 09:30	ENHANCING SILTY SAND RESERVOIR EVALUATION THROUGH INCORPORATION OF NMR LOGGING AND CORE DATA	**Christon Achong**	Saudi Aramco
09:30 – 09:45	Coffee Break		
09:45 – 10:15	QUANTIFYING THE EFFECTS OF HEAVY MINERALS ON THERMAL NEUTRON POROSITY IN SHALY SANDSTONE	**Pablo Saldungaray**	SLB
10:15 – 10:45	CHALLENGES AND SOLUTIONS IN THE PETROPHYSICAL CHARACTERIZATION OF DEEPWATER TURBIDITE DEPOSITS (THIN LAMINATED RESERVOIR)	**Ahmed Abouzaid**	Baker Hughes
10:45 – 11:00	Coffee Break		
11:00 – 11:30	INNOVATIVE AI-MODEL TO PREDICT TRUE SAND RESISTIVITY IN LAMINATED LOW RESISTIVITY SANDS	**Laila Alshammasi**	Saudi Aramco
11:30 – 13:00	Pray Time & Lunch Break		
13:00 – 13:30	THE ROLE OF DIGITAL ROCKS IN QUANTIFYING THE PROPERTIES OF HIGH-CONTRAST LAMINATED SYSTEMS	**Avrami Grader**	Halliburton
13:30 – 14:00	3D INVERSION THIN BED ID	**Ayman El-Khamry**	Saudi Aramco
14:00 – 14:15	Coffee Break		
14:15 – 15:15	Group discussion (3 groups)	**Avrami Grader, Pablo Saldungaray, Marie Van Steene, Ehab Najm & Taha Okashah**	
15:15 – 15:30	Summary & Closing Remarks	**Mark Ma, Faisal Enezi & Ahmed Hafez**	

Morning session

Saudi Arabia Chapter



Afternoon session

Saudi Arabia Chapter

13:00 – 13:30

Talk 6

13:30 – 14:00

Talk 7

14:00 – 14:15

Coffee break

14:15 – 15:15

Group discussion (3 groups)

15:15 – 15:30

Summary & Closing Remarks

Minimizing Uncertainties In Laminated Shaly Sand Using Advanced Petrophysical Technologies In Integrated Workflow - A Case Study

Saudi Arabia Chapter

Morning Session, Talk-1 (8:30 – 9:00 am)

Abstract

Micro and macroscopic-anisotropic reservoir characterization has, recently, been dealt with by two main approaches, 1) applying the Thomas-Stieber technique on uniaxial resistivity, or 2) applying the Tensor Model technique using multicomponent induction measurements.

The output from either technique is sand resistivity (RSand) and sand volume (VSand) with accurate water saturation (Sw) as a result of overcoming the effect of laminated shale on the resistivity measurement which will, eventually, translate into an enhanced hydrocarbon recovery and optimized reservoir development.

Some of the key challenges in both techniques are the proper understanding of total porosity and volume and the distribution of shale in the reservoir in terms of laminated and dispersed forms which if used in error will increase the uncertainty on processing results drastically. Additionally, the dependence of fluid density on saturation and the dependence of the saturation and cementation exponents (m and n) on the total porosity as well as the silty nature of the sand all add to the complexity.

The use of Oil Mud Resistivity Imager and Nuclear Magnetic Resonance logs as well as elemental analysis (if available) helped in confirming the laminated nature of the shale in the reservoir, minimizing the uncertainty in estimating total porosity and calculating clay-bound water (CBW). They also helped in accounting for the presence of silt-size sand.

This paper provides a complete rock model and a comprehensive workflow that takes into account all the necessary steps used to estimate water saturation in a thinly bedded sand-shale sequence, where both laminated and dispersed shale types can exist.

Also, the paper presents a simple sensitivity analysis done to understand the uncertainty of the processing parameters and estimated volumetrics on the results when using different techniques as compared to the proposed technique in this study. Data used in this paper are from a well drilled in the Malay Basin, offshore Malaysia.

HALLIBURTON

Ehab A Najm

Biography

Ehab A Najm is a Geoscience and Production Manager for Middle East North Africa (MENA) Region – Ehab holds an extensive experience in the petrophysics domain gained through 30+ years in both operator and energy services companies. He built and managed global mature fields solution center under wireline product service line to provide solution related to mature fields diagnostics. He led the subsurface team for unconventional reservoirs. Najm built different solution workflows to meet different challenges associated with clastic, carbonates, basement and unconventional gas reservoir/assets. He holds extensive experience in processing, interpreting and integrating all OH (either wireline and/or LWD), CH and surface data. Also, led the effort in introducing, processing and interpreting different wireline and/or LWD technologies. Najm Built and managed G&G centers in North Africa, Middle East and Asia Pacific regions

Enhancing Silty Sand Reservoir Evaluation Through Incorporation Of NMR Logging And Core Data

Saudi Arabia Chapter

Morning Session, Talk-2 (9:00 – 9:30 am)

Abstract

Prolific glacial clastic reservoirs, observed throughout the Paleozoic geologic record, produce alternating sand-silt-shale beds which are notoriously challenging to evaluate. Recent papers highlighted several workflows developed for defining sand, reservoir, and pay determination from these amalgamated stacked channel sands sequences. In particular, Graphical Density-Neutron (D-N) plots have been used successfully but require confident selection of clean sand, silt, and clay endpoints. Results are subsequently combined with Dual Water or Waxman-Smits models for reliable saturation determination.

NMR logging combined with MICP data allows for robust determination for the D-N endpoints for sand-silt-clay endmembers. NMR logging data also enables independent assessment of irreducible water saturation when reservoirs are above an assumed FWL, enabling cross-checking of the resistivity-based saturation results.

Incorporation of carefully selected sand-silt-clay D-N endpoints from NMR data enhances petrophysical workflow accuracy and precision. When conjoined with elemental and elastic logging responses, significant improvements in reservoir characterization and modeling are attainable.

The easy-to-use method has been utilized in several glacial clastic reservoirs with a variety of depositional environments and diagenetic footprints. Despite these geological variations, numerous examples presented from this work demonstrate solid consistency between the integrated log evaluation and specialty core analysis data.

أرامكو السعودية
saudi aramco

Christon Achong

Biography

Currently Christon with Saudi Aramco as a Petrophysicist; assigned to the Advanced Petrophysical Modelling Group within the Reservoir Description Division. Previously, Chris was with Royal Dutch Shell Group of Companies and ION Geophysical. He has participated in various stages of field development (exploration, appraisal, development, production) under operator and non-operator (NOV) conditions. Chris focus has shifted between conventional (offshore deep water) and unconventional (onshore tight sand gas/oil and shale gas/oil) play opportunities throughout his career. As a geoscientist within the upstream oil and gas sector, his goal is helping others find the right combination of technology and expertise deployment which boosts cash flow for the best opportunities. Specifically, leveraging shared experiences for opportunity framing, generating, & rapidly disseminating innovative technical solutions that impact the business. Chris holding a Ph.D. in Geochemistry, as well as a M.S. degree in Geology, a M.A.T. degree in Science Education, and a B.S. degree in Geological Sciences.

Quantifying The Effects Of Heavy Minerals On Thermal Neutron Porosity In Shaly Sandstone

Saudi Arabia Chapter

Morning Session, Talk-3 (9:45 – 10:15 am)

Abstract

Recent studies document the presence of rare earth elements and heavy minerals in Permo-Carboniferous sandstones of the Arabian Peninsula. The studies establish that the measure of the gadolinium concentration and the formation capture cross-section (sigma) are both good proxies for the rare earth elements and heavy minerals. The objective of this study is to assess, quantify and then correct for the effect of these rare earth elements on the thermal neutron porosity measurement.

Thermal and epithermal neutron porosity datasets were acquired in wells intersecting the Permo-Carboniferous sandstone. Relevant environmental corrections were applied to the data except for the formation water salinity correction. The hydrogen index values are obtained from the thermal neutron porosity measurement using corrections incorporating the measured sigma from the gamma ray spectroscopy tool and the formation bulk density. The measured sigma provides a measure of the water salinity in the flushed zone that is used to account for salinity effects on the thermal neutron porosity. The measured sigma also senses the effect of the heavy matrix minerals whose neutron capture cross-section is very high. The bulk density provides the required input to perform a density correction on the thermal neutron porosity.

The hydrogen index that results from the measured sigma and formation density corrections to the thermal neutron porosity is referenced to the epithermal neutron porosity for these Permo-Carboniferous sandstones. When shale is present, the computed hydrogen index shows small discrepancies from the epithermal neutron porosity. These discrepancies are due to minor remaining density effects on the epithermal neutron porosity. In clay free reservoir intervals and in zones with moderate gadolinium content, the matrix-corrected hydrogen index is essentially identical to the matrix-corrected epithermal neutron porosity. The corrections from the thermal neutron porosity to the hydrogen index amount to 1.5-2.0 pu in the clay free sands. Applying this process to another well, additionally shows a good agreement between the matrix-corrected hydrogen index and the hydrogen index from the nuclear magnetic resonance. A third and final well application illustrates the extreme effect that the presence of rare earth elements can have on the conventional thermal neutron porosity, with negative corrections up to 5 pu to obtain the hydrogen index.

Implementing a practical correction process to the thermal neutron porosity for the rare earth element bearing Permo-Carboniferous sandstones; this work quantifies the effects that rare earth elements have on the thermal neutron porosity measurements for the first time. This work is important for correct porosity evaluation in shaly formations that are likely to contain higher fractions of thermal neutron absorbers than clean formations.

Pablo Saldungaray

Biography

Pablo Saldungaray is a petrophysicist working for SLB, currently based in Al-Khobar, providing support for the planning, execution and interpretation of open and cased hole logs, with a focus on wireline services and petrophysical applications. Since joining Schlumberger as a Wireline engineer in 1989, he has held various positions in the field and data processing centers in Africa, Europe, Latin America and the Middle East. Pablo is an active member of the SPWLA and SPE, and participated in several papers for these societies and other industry related publications

Challenges And Solutions In The Petrophysical Characterization Of Deepwater Turbidite Deposits (Thin Laminated Reservoir)

Saudi Arabia Chapter

Morning Session, Talk-4 (10:15 – 10:45 am)

Abstract

Turbidite thin laminated evaluation in shaly sand environment can be limited when using conventional techniques and standard logging data such as density-neutron and resistivity. In this scenario, porosity can be underestimated across the main reservoir sections and water saturation can be overestimated across the interbedded reservoir laminations. Consequently, more advanced techniques are developed to overcome overlooked good quality reservoirs, as well as underestimated net pay.

The key in shaly-sand formation evaluation is to determine the true volume of the laminar shale. Also, the sand fraction porosity and sand fraction resistivity will be crucial to properly define the laminated sand petrophysical properties. Using advanced induction sensors and algorithms, tensor multicomponent resistivity measurement in the three orthogonal directions X, Y and Z can be used to calculate the vertical resistivity (Rv) perpendicular to the bedding plane, as well as the horizontal resistivity (Rh) parallel to the bedding plane. By simultaneously solving these resistivities, the volume of laminar shale, sand fraction porosity and sand fraction resistivity can be calculated. The resulting petrophysical model will significantly improve understanding of the reservoir and reduce uncertainties. This model is further improved with the added value from both Nuclear Magnetic Resonance (NMR) and improved Acoustic techniques. In fact, NMR free and bound fluids, grain size distribution, capillary pressure, relative permeability, and 2D NMR water saturation.

The integration of multicomponent resistivity, NMR and high-resolution acoustic data is implemented in a workflow to address the challenges related to the formation evaluation of thin laminated shaly-sand reservoirs that exhibit a low resistivity pay phenomena. The high-resolution data up to 6” vertical resolution have enhanced the laminated shaly sand analysis (LSSA) workflow results, as the workflow is able to resolve the thin laminated reservoir petrophysical properties such as porosity, permeability and lithology computations, once the laminar shale volume is discriminated, sand fraction petrophysical properties are derived and used for hydrocarbon saturation calculation. Resistivity and porosity of the sand fraction are more reliable, and representative. Potentially, this will result in additional pay zones, validation is achieved using wireline pressure testing and sampling tool across the identified zones with collected hydrocarbon samples.

Integration of reservoir characterization solutions from this workflow will help to address completion and production challenges, such as sand control optimization and smart ICD completion in laminated shaly-sand reservoirs.

Baker Hughes

Ahmed Abouzaid

Biography

Ahmed Abouzaid is currently Regional Formation evaluation SME – Baker Hughes - Reservoir Technical Services - RTS . Ahmed holds BSc. In Geology, Ahmed is an SPE & SPWLA member and worked along MENAT region. Ahmed has more than 20 years in oil and Gas industry in technical positions. Covering Operation Geology, Petrophysics, Rockphysics, Seismic Petrophysics for oil &gas operating and service companies Gupco-Bp, Fugro –Jason and Baker Hughes, Ahmed is leading the Petrophysics team in Baker Hughes Saudi Arabia supporting all the Petrophysics activities, Ahmed Achieved several integrated studies for clastics-carbonate reservoirs in middle east.

Innovative AI-model To Predict True Sand Resistivity In Laminated Low Resistivity Sands

Saudi Arabia Chapter

Morning Session, Talk-5 (11:00 – 11:30 am)

Abstract

Conventional resistivity logs by design will result in higher water saturation in laminated sands due to the laminated nature of the rock, the induction tools will show the interbedded sand/ shale sequences to have low resistivity values resulting in a reduced hydrocarbon pore volume in place.

Our workflow introduces a Machine Learning based algorithm that predicts true sands resistivity in laminated/ low resistivity sands when advanced tri-axial high-end resistivity logs are not available. The model utilizes basic resistivity-gr-density-neutron and produces Rand (true sand resistivity) for accurate reserves estimates.

This methodology will provide an accurate water saturation therefore a more precise reserves estimation. This workflow will allow the operator to go back in time even before the technology's introduction in early 2000's and generate the synthetic Rsand logs from basic triple-combo data.

Yacine Meridji

Biography

Yacine Meridji has 24 years of experience evaluating unconventional and conventional reservoirs in the oil and gas industry. He earned an MSc. in Data Analytics from Texas A&M University and is currently employed as a data scientist/petrophysicist with Saudi Aramco's Reservoir Description & Simulation Department. His main focus is to implement machine-learning workflows in petrophysics.

أرامكو السعودية
saudi aramco

Laila Alshammasi

Biography

Laila is a petrophysicist and a data science enthusiast with Reservoir Description Division; she graduated from Penn State University with Bachelors in petroleum engineering. Her current focus is initiating machine-learning projects to resolve daily ongoing formation evaluation challenges in the complex reservoir.

The role of digital rocks in quantifying the properties of high-contrast laminated systems

Saudi Arabia Chapter

Afternoon Session, Talk-6 (13:00 – 13:30 pm)

Abstract

The scope of the presentation is to reduce the uncertainty in defining reserves and productivity of stacked laminated formations exhibiting strong contrast in properties. The detection of high permeability streaks or thin-bed barriers play a role in resource assessment. The main objective is to advance the use of integrated core analysis in formations evaluation of such systems.

The well-known challenge posed by these formations is that most logs do not have the resolution and sensitivity to quantify properties with the details needed for constructing viable reservoir models representing sound recovery mechanisms. The presentation highlights this challenge and proposes the use of detailed physical and digital core analyses to define the properties of key rock members and then upscale the results by distributing the discrete properties into the well model. The process works closely with well logs. It is not a one solution the fits all cases. The challenges of specific cases need to be established so that a solution can be assembled.

A couple of examples will be presented. The main point of the presentation is not the specific solution to a challenge, but the integrated core analysis method applied. The contrast in layer properties has an impact on overall recovery mechanisms that control the productive life of the reservoir. Defining the contrast in properties using advanced formation evaluation is the main subject of the presentation.

Using digital and physical core analysis techniques can reduce the uncertainties in formation properties, reserve estimations, and expected productivity of a resource in its early stages of the formation evaluation process. The presentation advocates the integrated core analysis approach, physical and digital, as part of formation evaluation processes.

HALLIBURTON

SPWLA Global Distinguished Speaker

Avrami Grader

Biography

Dr. Avrami Grader is Core Analysis Domain Expert, Geosciences and Production, Halliburton. Avrami Grader interests are in multi-phase flow in porous media and reservoir heterogeneities. Formerly, a professor of petroleum engineering at Stanford and The Pennsylvania State University, Grader focused on two- and three-phase fluid flow in porous media, transient pressure analysis with its effects on well testing and water influx, and multi-phase flow dynamics in the near wellbore domain including wellbore mechanics. He served as Ingrain Chief Scientist for nine years and now with Halliburton as Domain Expert in the core analysis and integration within the Geosciences & Production group. He is heavily involved in all aspects of integrating physical and digital core analysis methods and log upscaling. He is currently a global distinguished speaker for SPWLA, as well as the chair of the SPWLA scholarship committee in Houston. He holds a PhD degree from Stanford University

3D inversion Thin Bed ID

Afternoon Session, Talk-7 (13:30 – 14:00 pm)

Abstract

Integrating the inversions of simultaneously acquired deep and ultra-deep logging while drilling (LWD) azimuthal resistivity measurements can improve the resolution of the overlapping volume under investigation and reduce uncertainty in the far field volume model reconstruction. Both are key tools for precise placement of horizontal wells, the recent enhancements in the downhole tools include surface processing algorithms and advanced visualization techniques that allow higher confidence in well placement decisions through improved understanding of subsurface geology and orientation of sand channels in real-time.

Ayman El-Khamry

Biography

Ayman is a petroleum engineering consultant at Saudi Aramco. Ayman started his career as an electric wireline logging engineer. He held several technical and managerial positions before moving to Saudi Aramco as a petroleum engineering specialist where he took part in various automation and remote operation projects and managed the deployment of numerous formation evaluation and well placement technologies. Ayman holds a Bachelor of Mechanical Engineering degree from Ain Shams University in Egypt, and is a member of several societies, including SPE and ASME