London Petrophysical Society

Petrophysics for Abandonment

Thursday 6th March 2025
Geological Society, Burlington House, London
09:00-17:00 GMT

London Petrophysical Society - "Petrophysics for Abandonment" - Thursday 6 March 2025				
Start Time	End Time	Name	Company	Talk Title
09:00	09:15	Doors Open and Registration		
09:15	09:25	Edwin Wraith	LPS	LPS Seminars - Introduction
09:25	10:00	Iain Whyte	Tullow Oil	Petrophysics underpins everything about abandonments – Flow Zones to New Tech
10:00	10:35	Laura Martel	Halliburton	A case study of integrated well integrity measurement for CO2 injector well candidate
10:35	11:10	Paul Taylor	Multiphase Analytics	Identification of Fluid Leak Pathways in and Around Wellbores via Analysis of Surface Samples
11:10	11:30	Break		
11:30	12:05	Benamin Taylor	Baker Hughes	To cut or not to cut, that is the question" – Independent & reliable technologies to assess downhole tubular status for cut & pull operations
12:05	12:40	Maciej Pawlowski	Weatherford	Importance of Well integrity logging in P&A operations.
12:40	13:15	Johana Reyes	Halliburton	Reducing the Uncertainty in Heavy Oil Saturation Analysis in a Complex Well by using Pulsed Neutron Log. A Case Study in Boscan Superior Field, Venezuela
13:15	14:15	Lunch		
14:15	14:50	John Burns	Islay Subsurface & Engineering	Squeezing natural barriers; using conventional and novel new techniques to evaluate squeeze potential
14:50	15:25	Alhadi Zahmuwl	SLB	Behind-Casing Fluid Typing Using Ultrasonic Logs for Plug and Abandonment Applications: Enhancing Efficiency
15:25	15:45	Break		
15:45	16:20	Aditya Arie Wijaya	Halliburton	Pulsed Neutron Petrophysics in Well Integrity – Identifying Water Source in Production Well
16:20	16:55	Panel Discussion		
16:55	17:00	Philip Gibbons	LPS	LPS President - Closing Remarks
17:00	Networking Reception in the Library			

Register via the LPS website: https://lps.org.uk/events/

Petrophysics underpins everything about abandonments – Flow zones to New Tech

Iain Whyte; Tullow Oil

We are all well aware that the Petrophysics discipline covers a diverse and broad subject range, with wide ranging skills and experience required. This is equally true in the field of abandonment planning and execution. The Petrophysicist will be called upon to support everything from compiling the Subsurface Basis of Design for Abandonment and identification of "zones with potential to flow", to identifying barriers, and indeed where barriers should be placed. The skills and techniques required are often not entirely straightforward, for example what is the definition of a "zone with potential to flow" anyway? How does one define what will flow, and possibly more importantly what will NOT flow!

In terms of barriers, both those introduced and natural, the Petrophysicist will be required to identify where Annular Barrier(s) are required to be placed, and indeed there is a high value to the prize of eliminating unnecessary barriers where it is safe and possible to do so. Where AB2 barrier can be removed, this reduces time, risk and cost to the operator during abandonment, and may even change the vessel strategy for intervention from rig based to Light Well Intervention Vessel based approach.

The Petrophysicist is often called upon to evaluate cement logs, and should avoid the pitfalls of a simplistic 10 mV cut off for a CBL analysis and be able to identify poor data quality as opposed to poor bond! We will discuss appropriate cut offs and methodology for cement evaluation of "good" bond, and indeed those for cut & pull operations.

The Petrophysicist, as always, will seek to exhaust data sources and reduce uncertainty in answers where possible, while at same time being conscious of cost, and with an aim to again reduce complexity, risk and cost. They will look to utilise natural squeezing barriers where possible, and evaluate the same to determine their sealing potential.

One of the Holy Grails of abandonment is to avoid removal of the tubing during operations and to execute "through tubing abandonment". The Petrophysicist may choose to utilise the developing technology of "Through Tubing Logging" for evaluation, but in doing so must be extremely conscious of the measurement limitations and reliability. It is a fast moving technology and different vendors have chosen quite different approaches in the measurement.

Iain Whyte *graduated from Robert Gordon University with a Hons degree in Applied Physics in 1995. In 1996 he joined Atlas Wireline Services as a Cased Hole Wireline Engineer, which later became Western Atlas, Baker Atlas and ultimately Baker Hughes. The role took him all over the world, logging in diverse circumstances! In 2003 Iain joined Wellserv (Weatherford) as General Field Engineer. In 2004 he joined BP to support Black Sea exploration offshore Turkey. He stayed at BP until 2010 covering Operations and Studies Petrophysics in Norway, Angola and Azerbaijan. In December 2010 Iain started Islay Petrophysics LTD, predominantly to work for Tullow Oil as Group Lead of Petrophysics Operations. 14 years later, Iain still consults to Tullow, but has also grown the consultancy company into what is now Islay Subsurface & Engineering LTD. Iain has served in various positions on LPS Committee, including President and Past President roles. Iain grew up as a farmer and whisky distiller's son on the tiny Island of Islay he still calls "home".*

A case study of integrated well integrity measurement for CO2 injector well candidate

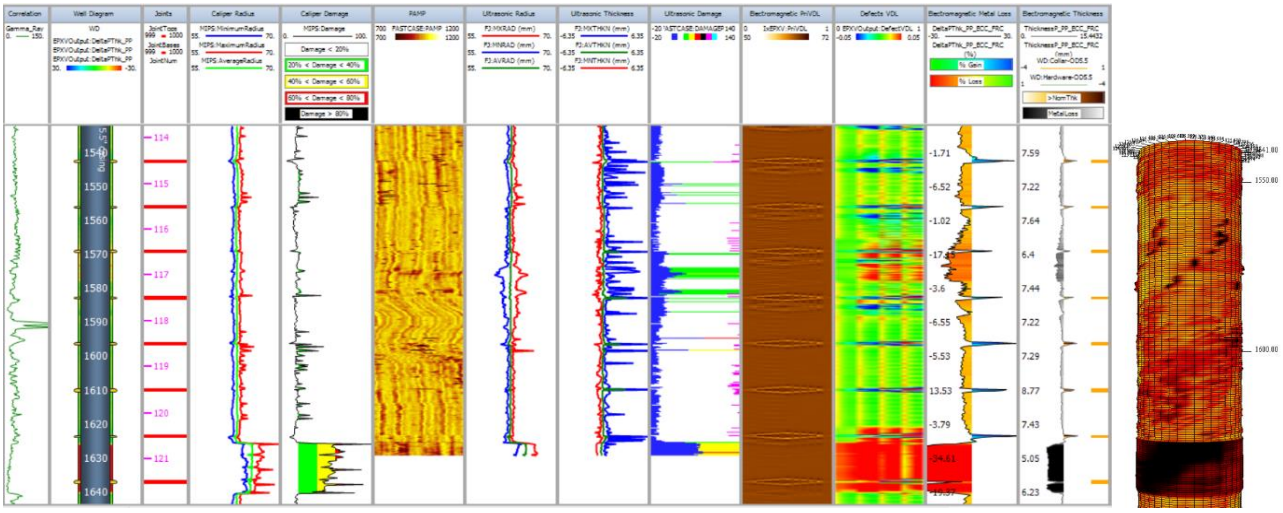
Laura Martel, Johana Reyes, Ulimaz Dhania, Jatinder Kumar, Alfredo Bustillo; Halliburton
Anette Goldbach; Gas Storage Denmark A/D

CCS projects have an important mission for every country government and the energy companies. Modern technology and process were developed to support the well risk assessment. Starting from the plan phase, there are crucial factors to be considered when planning and designing a CCS project, and one of this is to choose the best candidate well for the CO2 injection. The well under study was initially drilled for gas monitoring and water injection, a thorough well integrity analysis should be done before converting it into the CO2 injector well. A comprehensive well integrity analysis will bring the confidence of a success injection of CO2 into the targeted underground storage over the life of the project.

For detailed well integrity analysis higher vertical resolution and good circumferential coverage can be met by combining conventional caliper with ultrasonic and electromagnetic technologies. The 40-fingers caliper and ultrasonic provide the real condition of the ID and image the thickness of the inner pipe, while the electromagnetic provides the comprehensive pipe thickness measurement of the inner tubing and 2 external casing. The integration of all the data from the three sensors (Fig.1) provided a better understanding of the structural integrity which is a key step in the well risk assessment and qualifying the well as a candidate for CO2 injection.

In this study, good agreement on both internal radius reading from 40-fingers caliper and ultrasonic radius measurement indicated casing pitting and corrosion in the inner wall of the first tubular. Thickness measurement from electromagnetic and ultrasonic confirmed the inner casing pitting and corrosion with increasing metal loss. The 3D-images and cross-sections supported the analysis by showing better visualization of the casing inner condition. Computation of metal loss and the remaining wall thickness of the casing plays significant role to decide the ability of the casing to hold the injection pressure.

By identifying and addressing risks upfront, operators can reduce uncertainties and enhance the reliability of carbon capture and storage (CCS) projects. Based on these findings, the well does not meet the technical and regulatory criteria required for CO_2 injection and storage.



Laura Martel *currently works as a Senior Solution Advisor for Halliburton Europe. She earned her degree in Petroleum Engineering from the Universidad Nacional de Cuyo in Argentina and later an Executive MBA from ADEN University in Panama. Laura has more than 15 years of experience in geosciences and petrophysics. She focuses mainly on well intervention solutions and has global experience developed working for different clients in more than twenty countries, mainly in Latin America, Europe and Asia Pacific.*

Identification of Fluid Leak Pathways in and Around Wellbores via Analysis of Surface Samples

Paul Taylor, Erik Tegelaar; Multiphase Analytics

A thorough assessment of well integrity is a critical work element prior to abandonment if effective isolation of hydrocarbon bearing intervals is to be achieved. However, the combined effects of corrosion, scale and abrasion over time means that one or more well barriers is often compromised. This can result in the loss of well integrity and the migration of hydrocarbon fluids to surface, causing sustained annulus pressure (SAP). The presence of SAP may have numerous causes – a typical well may have thousands of potential leakage pathways – each having different safety consequences and requiring a different remediation strategy.

A variety of logging technologies are available to identify leak points within wells, but they may not provide a definitive assessment of leak pathways if leakage rates are low and/or behind pipe. Moreover, well construction may preclude the use of wireline tools throughout the full well bore.

Forensic analysis of surface gases may be used to determine their subsurface origin and so constrain leakage pathways. Molecular composition of gases and stable carbon & deuterium isotope analysis of individual gas components can provide a detailed gas "fingerprint" that can be used to track gas flows from their geologic origin to their accumulation point; thus narrowing down the potential leak pathways and permitting more efficient remediation. Previously, the primary limitation of such techniques was the absence of reference gas data throughout the drilled section to permit correlation with surface gases. Gas isotope calibration profiles were occasionally collected using mud gas samples, but such exercises were rare, and required planning to execute at the time of drilling.

We have developed a novel technology that permits the generation of gas composition and isotope profiles from the analysis of very small samples of unpreserved cuttings. This means that calibration gas profiles can now be generated from legacy cuttings samples, and on specific lithologies to create robust reference gas data to pin-point the subsurface origin of hydrocarbons leaking in and around the wellbore.

This presentation will provide an overview of the technology and show examples of its use in determining the precise origin of gas leaking from an abandoned onshore well.

Paul Taylor *is a consultant geochemist with almost 30 years' experience of developing and applying fluid analysis technology within oil and gas operating companies worldwide. He was previously Principal Technical Expert and Discipline Lead for Geochemistry for Shell.*

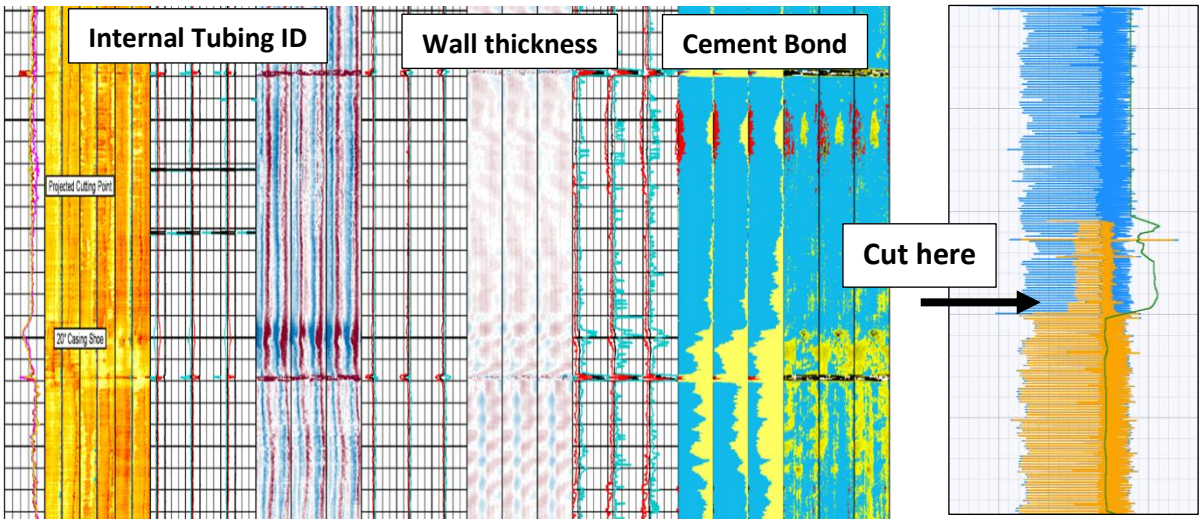
“To cut or not to cut, that is the question” – Independent & reliable technologies to assess downhole tubular status for cut & pull operations

Benjamin Taylor, Andy Hawthorn; Baker Hughes

Designing an abandonment programme will inevitably include a series of acquisition trips using a combination of technologies to determine a range of downhole conditions – bonding, micro-annuli, casing integrity & formation swell. The final decision based on the data acquired might be the depth to cut the pipe for the cut & pull phase.

High expectation on operational efficiency requires cutting and pulling pipe during the abandonment phase to be a predictable and critically, a one-time event for the operator. A rig on stand-by while repeatedly shallower cuts are made, with successive pull attempts, not only adds time, cost & carbon emissions to the programme but leads to downhole complexities with multiple separated pipe sections being created.

The presentation will describe different technologies that together provide the most complete answer of tubular logging for abandonment. Case studies will be presented on drill-pipe conveyed tubular and cement integrity using pulse echo technology in deepwater West Africa, as well as electric line conveyed pipe recovery technology from a large abandonment programme in US land.



Benjamin Taylor *is the Global Product Manager for Baker Hughes, Wireline Services based in London. His focus areas are electric line intervention, pipe recovery & deployment solutions. Benjamin has worked in the energy industry for almost 20 years, holding a range of international assignments starting in the field, encompassing operations, technology and general management. Benjamin graduated with a MSc (Hons) Degree in Petroleum Geoscience from the University of Manchester, UK.*

Andy Hawthorn *is the Global Solutions manager for Smart Services at Baker Hughes. He has degrees in Geology and Geotechnical Engineering from the University of Durham, UK. He has been involved with the development of downhole tool technology for the last 25 years and before that worked internationally around the world in drilling and logging. He is widely published and holds numerous patents in the field of acoustics, geomechanics, drilling and earth model building.*

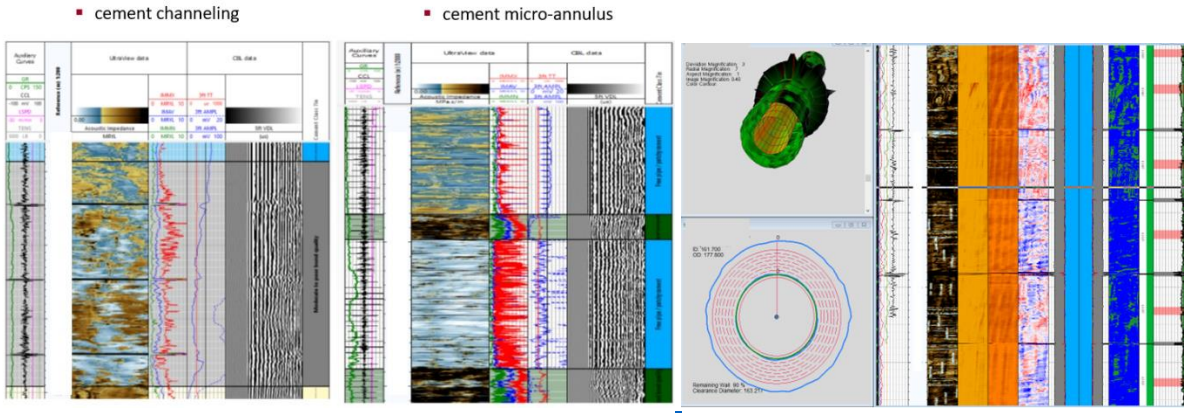
Importance of Well integrity logging in P&A operations.

Maciej Pawlowski; Weatherford

Plug and abandonment no longer economically viable wellbores is a complex process that presents technical, operational, and economic challenges. To restore initial cap rock functionality disturbed by drilling the wellbore, cement plugs placed in P&A operations must cover full cross section of the wellbore, both horizontally and vertically. Wellbore diagnostic technologies usually deployed via E-Line conveyance are used to verify effectiveness of the plug placement in the casing annulus. Barrier needs to be hydraulicly isolated from the surrounding formation to prevent flow of hydrocarbons or any other pressurized fluid through the barrier. In cases where cement bond logs indicate incomplete bonding, cement needs to be fixed. That is usually achieved through some type of remediation operation. Interpretation of the cement bond logs allows to identify type of cement debonding what is necessary to choose optimum remediation techniques e.g., per-wash-seal recommended for larger size cement channeling issues, or section mill for small size cement micro-annuli gaps.

Combination of conventional CBL log together with pulse-echo ultrasonic log gives a complete picture of bonding between casing-cement and cement-formation interfaces. Acoustic impedance of the material behind the casing from pulsed echo ultrasonic tools provides the means for detailed high resolution 360deg. coverage cement evaluation with the option to differentiate between water, cement, and gas content within the casing annulus. Additionally, advanced data interpretation techniques allow to identify squeezed formation within annular space as a barrier element.

Condition of the casing itself can be evaluated with circumferential casing thickness, radiuses, and amplitude maps from ultrasonic logs which when combined with a high-resolution multi-arm caliper and magnetic flux-leakage tools will identify any type of casing imperfection, from general corrosion, wear, pitting to deformation that is commonly observed in mature filed wells as a result of squeezed formation. Some service companies allow to perform all four measurements in the single logging trip what significantly reduce rig time – significant cost of P&A operation as well as to reduce overall carbon footprint.



Maciej Pawlowski *is the Senior Geozone Petrophysicist at Weatherford's Interpretation and Evaluation Services (IES) department. In this role he is responsible of quality analysis, processing, interpretation and evaluation of Wireline logging data in North Sea, Continental Europe, Caspian, Sub-Sahara and West Africa regions.*

Reducing the Uncertainty in Heavy Oil Saturation Analysis in a Complex Well by using Pulsed Neutron Log. A Case Study in Boscan Superior Field, Venezuela

Johana Reyes, Jose Mata, Zunerge Guevara; Halliburton
Oneida Leon, Nolcry Valera; Petroboscan

Major operating companies in the current oil market are experiencing three major challenges: minimizing costs, operating efficiently, and maximizing production. Worldwide, approximately 70% of the hydrocarbon production comes from mature fields; consequently, this topic has become an object of research to improve hydrocarbon production in countries whose economies primarily depend on hydrocarbon production. These mature fields require studies or techniques that enable estimating and later increasing their recovery factor. One of the techniques used is the monitoring and surveillance of the reservoir fluids in cased hole conditions.

The best practice to evaluate formation fluids in mature fields is the use of saturations logs, the most successfully used of which is the Pulsed Neutron Log (PNL) tool. The PNL tool uses induced gamma ray spectroscopy and decay time measurements to calculate fluids saturations in the formation. It can provide information about sigma saturation in more saline reservoirs and carbon/oxygen ratio (C/O) to determine the oil saturation, independent of its water salinity.

The completion of the well under study include a slotted liner with internal filters that entrap the heavy oil during production. This complex completion represents a major challenge in Boscan fields because of the added environmental impact on the log data which is required to identify the current hydrocarbons saturation and to determine the current oil-water contact (OWC) depth to enable better field exploitation planning. This success case describes a detailed methodology used to mitigate uncertainty in heavy oil saturation estimation arising from these adverse environmental effects.

Reducing uncertainty is an essential component to determine remaining oil saturations and to efficiently manage reservoir production. A detailed petrophysical analysis computed with open hole logs was integrated with the pulsed neutron saturation (fig.1), applying the appropriated environmental correction to mitigate uncertainty, identifying a hydrocarbon zone with 60% of undrained heavy oil saturation, and defining the current depth of OWC.

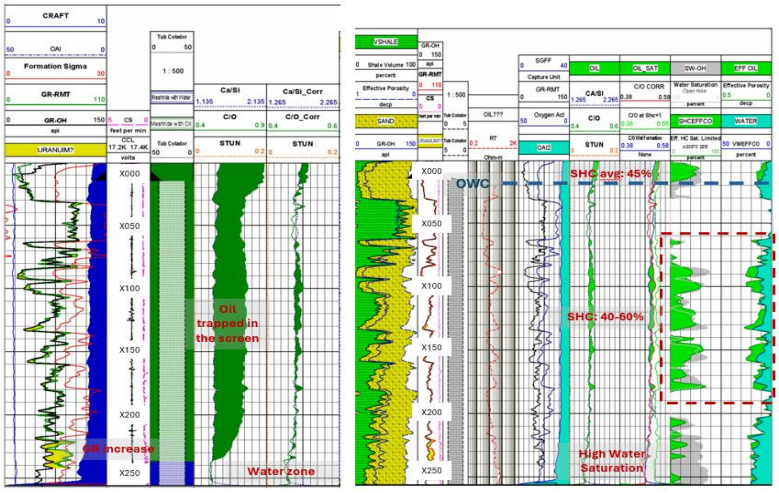


Fig.1. Saturation analysis.

Johana Reyes *is a Petrophysics for Halliburton. She joined Halliburton in 2013. Her experience includes log interpretation, mostly specializing in pulsed neutron log and Well Integrity Analysis. She is part of the G&P Center of Excellence EESSA team and holds a bachelor's degree in petroleum engineering from La Universidad del Zulia-LUZ, and a Master of Manager Enterprise from same University.*

Squeezing Natural Barriers; Using conventional and novel new techniques to evaluate squeeze potential

John Burns; Islay Subsurface & Engineering

The utilisation of squeezing natural barriers for abandonment has become a very hot topic, and provides enormous potential to reduce complexity, risk and cost in the abandonment phase. The speaker will introduce what properties are required from a squeezing natural barrier to provide isolation, and how we might characterise and evaluate that potential. It is now fairly conventional to search for formations with potential to squeeze from the Composite Log compiled by mud loggers and Well Site Geologist at time of drilling. The zones are typically regionally known for this potential from offset wells, but rarely is any "quantitative" assessment of the squeeze potential made. The speaker will introduce a workflow and technique used to evaluate squeeze potential, that is performed in advance of any intervention, or indeed any Basis of Design composition. The speaker will discuss the value of this early information in terms of targeting an approach for utilising squeezing natural barriers, and how a numerical approach has substantial advantages over a conventional probabilistic technique.

Behind-Casing Fluid Typing Using Ultrasonic Logs for Plug and Abandonment Applications: Enhancing Efficiency

Alhadi Zahmuwl; SLB

Ultrasonic imaging tools have traditionally been used for cement bond evaluation and pipe condition assessment. However, in plug and abandonment (P&A) operations, there is a growing need to characterize fluids behind casing to ensure safe circulation before casing recovery. This is particularly critical in offshore wells with integrity challenges, where unintentional hydrocarbon circulation can lead to safety risks, operational delays, and potential platform shutdowns.

In a North Sea P&A case, determining whether hydrocarbons were present in the B annulus (13-3/8'' x 9-5/8'') was essential. The platform lacked infrastructure to safely route annular fluids to processing facilities, and the rig well control equipment was not designed to separate crude oil from oil-based mud. Any crude oil in the returns would flow directly into the mud pits, creating a significant safety hazard. To mitigate this risk, a bleed-off package would need to be mobilized for safe containment if hydrocarbons were detected.

Over the well's lifespan, annular fluid composition degraded due to gravity and fluid migration, raising uncertainties about its contents. Traditional ultrasonic pulse-echo technology proved inadequate for fluid identification, necessitating an advanced solution. A next-generation ultrasonic tool, integrating pulse-echo and pitch-catch techniques, was deployed to classify annular fluids using flexural attenuation, Third Interface Echo (TIE) data, and acoustic pseudo-density analysis. This novel workflow accurately identified annular fluid distribution before circulation, aligning with actual circulation results.

Annular fluid characterization data was acquired while pulling out of hole (POOH) in the same descent where cement evaluation logging was required to confirm reservoir isolation in the deeper section of the well. Detecting oil in the annulus at this stage still allowed the operator to plan and mobilize the test package, as the next operation involved setting a deep isolation plug followed by the casing cut. This proactive approach provided critical insights, enabling hydrocarbons to be detected prior to casing cutting, reducing the need for premature well test package mobilization.

By accurately characterizing annular fluids, the workflow minimized safety risks, optimized logistics, and prevented costly platform shutdowns. The successful application of this ultrasonic fluid characterization workflow improved efficiency and enhanced the safety of the P&A operation, ensuring minimal operational disruptions on a producing platform

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Alhadi Zahmuwl *is a Production Services Domain Champion at SLB, providing technical support for cased hole wireline logging acquisition and data interpretation. With over 20 years of experience in production logging, cement evaluation, well integrity, well interventions, and P&A operations, he promotes advanced technology and integrated solutions to enhance well performance. He has contributed to numerous P&A projects, including the Brent Charlie and DNO's Schooner fields and has authored several technical publications.*

Pulsed Neutron Petrophysics in Well Integrity – Identifying Water Source in Production Well

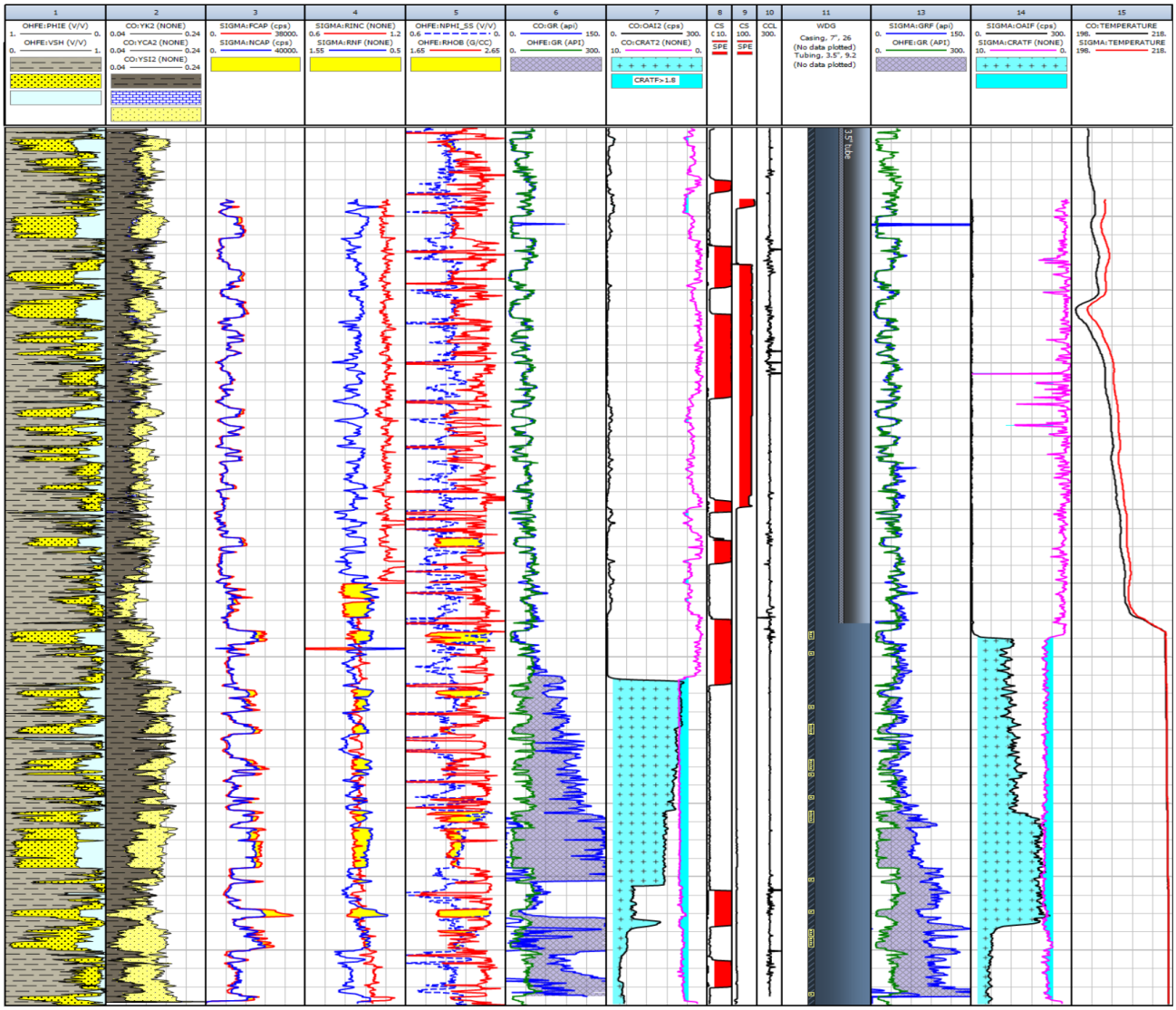
Aditya Arie Wijaya; Halliburton
Johanes Prasetyo, Yudi Handradika, Sulistyo Pratomo; Pertamina Hulu Kalimantan Timur

Objectives/Scope
Cased hole pulsed neutron (PN) tools have many applications. Apart from mainly used to determine the hydrocarbon saturation behind casing, it can also be used to evaluate the well integrity. A well has been logged with PN tools with objective to evaluate remaining hydrocarbon saturation. Further investigation reveals that it has well integrity issues of multiple zones producing water, theft zones (taking fluid), and possible leaking – which later was confirmed by operator. This paper discusses the other application of PN tools that often overlooked – Oxygen Activation (OA) data in identifying integrity issues, particularly in mature field where the well has been undergone many process (productions, completion, etc).

Methods, Procedures, Processes
The oxygen activation is a background measurement of pulsed neutron logging. It characterizes by the low energy gamma ray that was generated by the activation of oxygen after getting radiated by the tool. This oxygen is assumed to be associated with water movement can induced a continuous measurement of oxygen activation (OA) counts that corresponds to; the volume of the water, velocity of the water, and the vicinity to the water. In front of zone with water movement, OA reading will be higher than zone with no water movement. It also commonly known by experience, that across zone with highly producing water, the gamma ray is typically elevated due to NORM/ scaling. Both of which are pronounce in the well.
And since the logging took two passes of CO and Sigma, the combination of those data will be used to evaluate and estimate where the producing water zone is, where is it located (behind pipe/ inside wellbore), and if there is any crossflow and/or leak in the well.

Results, Observations, Conclusions
The result shows a compelling story of the well, where some perforated zones is highly indicative to be a water-producing zones, where others are taking the fluid (theft zone) – which concludes as crossflow. Across all the producing zones, it can also be qualitatively indicated which zone producing water the highest. All these observations from OA data, align with the cased hole gamma ray log increase- which further support the interpretation. Moreover, based on the OA data, it is also highly likely that the bridge plug located at the bottom of the logged data is leaking as the water flow is coming from bottom section as indicated by Compton ratio from OA data.

Novel/Additive Information
The case study highlights the usefulness of OA data in identifying integrity issue in the well. The use of OA data alongside CH GR are proved to be highly correlated to the presence of water producing zones – which can be associated with possible crossflow, plug leaking, or theft zones.



Aditya Arie Wijaya *is a Petrophysicist for Halliburton Geoscience & Production of EESSA region. He has over 12 years of experience in cased and open hole petrophysics across five continents. He has interests in low resistivity pay-low contrast reservoir, integrated petrophysics, and well integrity. He has authored multiple publications, and a member of SPWLA and SPE.*