Aberdeen Formation Evaluation Society

AFES 2020 Seminar

Core: the most valuable asset in your reservoir

2nd & 9th September 2020 - Virtual Event

Due to the ongoing COVID-19 pandemic, AFES will be holding their Coring Seminar as a 100% webinar based event. AFES will host this event over 2 webinar sessions on consecutive Wednesdays

This event is free to attend, and we envisage delegates will attend on a drop in / drop out basis.

This event is open to AFES Members and also non AFES Members

To register:

https://www.eventbrite.co.uk/e/afes-2020-seminar-tickets-117394834109

…or contact Stephen Morris (Stephen.Morris@BakerHughes.com)

SESSION 1 - Wednesday 2nd September 2020				
13:00	13:15	AFES		Opening Slides
13:15	14:00	Keynote: Iulian Hulea	Shell Global Solutions BV	Understanding fundamental controls of hydrocarbon saturation: from stress corrections to perched water contacts
14:00	14:30	Craig Lindsay	Core Specialist Services	Big Data From Core – Multi-Sensor Core Logging Case Study
14:30	15:00	Adam Moss	AKM Geoconsulting Ltd.	Successful Core Analysis – A Lab & Opco Perspective
15:00	15:30	Quentin Fisher	University of Leeds	Core analysis as part of the fault property prediction workflow
15:30	16:00	Izaskun Zubizarreta	Indar Solutions	Core wettability - can we get it right?

SESSION 2 - Wednesday 9nd September 2020				
09:00	09:30	Colin McPhee	Mercat Energy Limited	SCAL Data Quality Control for Static & Dynamic Reservoir Modelling: A Case Study
09:30	10:00	Philippe Rabiller	RABILLER Geo-Consulting	Capillary Pressure - An Integrated Flow Chart For Carbonate Reservoir Characterization From Resource Assessment To Field Development And EOR Applications
10:00	10:30	Alan Swanson	Core Laboratories (U.K.) Ltd	Dual Energy CT Scanning – Millimeter-Scale Log for Cored Intervals
10:30	11:00	Henk Kombrink	North Sea Core	The Second and Not So Secret Life of Core with the North Sea Core Initiative
11:00	11:30	Chris Reed	Mercat Energy Limited	Integration of Continuous Core Strength Measurements and Rock Mechanics Tests for Optimised Strength Models in Geomechanics Applications
11:30	11:35	AFES		Closing remarks

third release 28 August 2020

AFES 2020 Seminar

Core: the most valuable asset in your reservoir

2nd & 9th September 2020 - Virtual Event

Iulian Hulea – Shell Gloal Solutions BV

Understanding fundamental controls of hydrocarbon saturation: from stress corrections to perched water contacts

Building realistic and reliable subsurface models requires detailed knowledge of both the rock and fluids involved. While the hydrocarbon volume estimation has a profound impact on the viability of a development, next to the permeability, saturation height models, free fluid levels and the hydraulic communication have a significant role in determining the recoverable reserves.

When in different parts of the same field different free fluid levels (leading to different fluid contacts for the same rock quality) are identified, the lateral hydraulic communication at the field level can be challenged. In this presentation, we propose a new strategy in studying one process leading to different free water levels (FWL) known as "perched" water contacts. Perched water contacts are the result of water entrapment (behind barriers for lateral flow) during hydrocarbon migration in the reservoir. The fundamental controls that lead to the perched contacts formation are studied and shown to be the rock quality and relative permeability. Counterintuitively, the perching effect is not going to feature in poor quality rocks (sub-milli Darcy permeability) – the effects would be visible only for a considerable barrier height. Regarding transition zones, the results show no significant difference is expected above the perched zone when compared to the unconstrained parts of the field. Field observations and dynamic simulations are used to identify the perching controls. A clear distinction is shown between capillary pressure and buoyancy. The fundamental assumption that the capillary pressure can be calculated by using the height above free water level is shown to be deficient when water becomes immobile.

Concerning the process of building a Saturation Height Model from core measurements, we use a recent methodology that aims at ensuring consistency between permeability and Saturation height. The MICP or Saturation height model carries an intrinsic permeability that can be compared to the permeability model. The results show a significant inconsistency can occur between the porosity -permeability data (a reliable, well controlled and measurable property under stress) on one hand and the MICP/SHM inferred permeability on the other. The conclusion is that the most robust dataset for preparing the SHM is under the conditions the MICPs/PCs have been acquired. When the MICPs/PCs have been acquired under ambient conditions and the resulting model has as inputs stressed porosity and permeability, the SHM will predict the correct stressed entry pressures. The findings are validated against a dataset where the capillary pressures acquired under both ambient and stress conditions.

Aberdeen Formation Evaluation Society

SOCIETY OF PETROPHYSICISTS AND WELL LOG ANALYSTS

AFES 2020 Seminar

Core: the most valuable asset in your reservoir

2nd & 9th September 2020 - Virtual Event

Craig Lindsay – Core Specialist Services

Big Data From Core – Multi-Sensor Core Logging Case Study

Industry standard methodology for core analysis over the past 80 years or so, is to acquire data from core plugs at fixed interval spacing – a compromise between cost & practicality. For routine core analysis (RCA) this represents < 10% of the possible rock volume and for special core analysis (SCAL) as little as 1%. This means that the resultant data is unlikely to be representative unless the rock is extremely homogeneous. For advanced studies including SCAL, geomechanics, petrography, geochemistry etc. it is extremely important that test samples are selected as representative of the range of properties represented by the core.

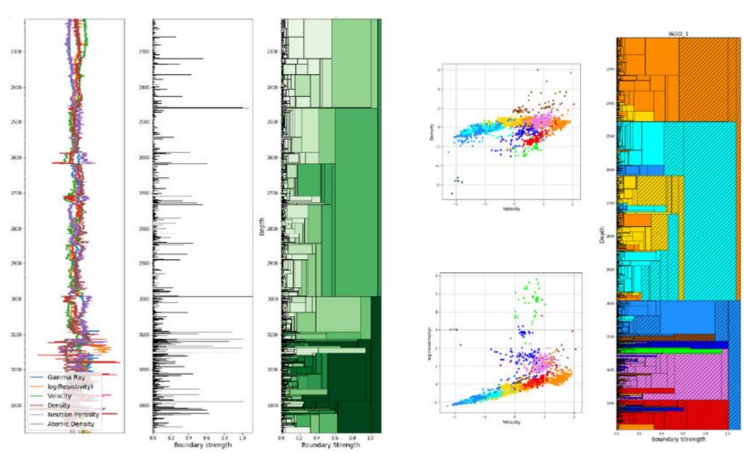
Yet technologies exist to acquire continuous, high resolution, multi-sensor data – such as 3D X-Ray CT (not micro), resistivity, magnetic susceptibility, hyper-spectral imaging, infra-red, compressional & shear sonic & X-Ray Fluorescence.

Whilst some of the data types may not have a clear initial correlation with reservoir properties of interest (which is why we acquire and analyse cores) the detailed analysis & extraction of correlations between data types may enable a new approach to rock type and core description to be developed. The ultimate objective is develop a "Petrophysical Core Log" which is free of bias introduced by manual core log / descriptions. Herein we have the ability to produce fully comparable core logs at any place or time.

A case study is presented using core from the UKCS Dunlin field. An extensive set of well log and core analysis data was also available from the UK's Oil and Gas Authority, National Data Repository (NDR) – a vast resource of well data with open access. The data derived from multi-sensor core logging (MSCL) has been combined with the well data (core and log) and analysed using machine learning to develop a prototype "Petrophysical Core Log".

Core materials kindly available by Fairfield Energy as a permanent donation as a part of the field decommissioning on Dunlin.

Multi-sensor core logging performed by Geotek Limited, UK.



third release 28 August 2020

AFES 2020 Seminar

Core: the most valuable asset in your reservoir

2nd & 9th September 2020 - Virtual Event

Adam Moss – AKM Geoconsulting Ltd.

Successful Core Analysis – A Lab & Opco Perspective

Core provides the only direct and quantitative measurement of reservoir rocks and should provide the foundation on which formation evaluation rests. The benefits of an appropriate and focused core analysis programme far outweigh the relatively minor costs associated with cutting and testing the core. The economics are driven by reducing the uncertainty in formation properties.

Within most companies, the petrophysicist is tasked with managing the acquisition of log and core data. Geologists, reservoir engineers, petroleum technologists and drillers should all have input into a data acquisition and analysis workflows. It is vital to ensure that the goals and objectives of all disciplines are known and understood prior to initiating such work. The link with the laboratory is a vital one and the importance of a good operator-lab relationship cannot be overstated. Following successful data acquisition, it is of equal importance to ensure that effective integration and application of the data takes place. Successful core data integration will help to reduce reservoir uncertainties in key areas for prospect development, for example: Hydrocarbon Initially In-Place, Recoverable Reserves and Project De-Risking

This paper presents strategies for delivering successful analysis programmes and demonstrates the importance of using appropriate core analysis data in petrophysical and reservoir models. Examples of how core analysis data has been used as a primary input into saturation height functions, calibrated resistivity and NMR saturation and permeability models, will be discussed from a wide variety of reservoirs and rock types. Finally, the author will present some case studies demonstrating successful and challenging projects which exemplify key issues in core analysis project management.

Quentin Fisher – University of Leeds

Core analysis as part of the fault property prediction workflow

Faults can have a significant impact on fluid flow in petroleum reservoirs. Uncertainty about their flow properties can lead to significant uncertainties regarding the economics of field development. Analysis of core can, however, provide the basic data needed to model the impact of faults on fluid flow allowing better production forecasts and field management.

Examination of core provides a rapid and reliable method to quickly assess whether faults are likely to be barriers or conduits for flow. Logging the structural features in core provides important information on fault zone architecture (fault spacing, fault thickness etc.), which can be incorporated into flow models. Structural logs can be used to ground-truth FMI data to increase confidence in the determination of faults and fractures from wells or parts of wells where core has not been taken.

If it seems possible that faults are going to act as barriers to fluid samples can be collected for microstructural and petrophysical property analysis. The permeability, relative permeability and capillary pressure of fault rocks can be measured at reservoir conditions. Quantitative XRD can be undertaken to determine the clay content of the faults. Integration of the data can be used to create reservoir-specific relationships between the clay content of fault rocks and their flow properties. The data can then be incorporated into fault analysis software such as Transgen to calculate fault transmissibility multipliers, which can be used in production simulation models to account for the impact of faults on subsurface flow.

third release 28 August 2020

AFES 2020 Seminar

Core: the most valuable asset in your reservoir

2nd & 9th September 2020 - Virtual Event

Izaskun Zubizarreta – Indar Solutions

Core wettability - can we get it right?

Wettability is the fundamental attribute controlling reservoir fluid saturations. It is the main parameter governing capillary pressure, which determines the distribution of the fluids, and relative permeability, which describes the fluid dynamics, within porous media. It is essential that wettability in a core study is "representative" of the reservoir wettability and thus, one must decide whether native (fresh or "as received") state or restored state analysis should be employed. To date, there remains debate in our industry regarding which of these two conditions should be more representative: some preferring native state and others favouring restored state core procedures. This talk introduces the processes and variables that affect or could affect the wettability of the core from subsurface, surface, lab and testing, and should help engineers and geoscientist to judge if any particular initial state is likely or not to be considered "representative" of the reservoir wettability.

Colin McPhee – Mercat Energy Limited

SCAL Data Quality Control for Static & Dynamic Reservoir Modelling: A Case Study

Reliable and representative SCAL data provide essential data input to both static and dynamic reservoir models yet McPhee et al (2015) suggests that much SCAL data might not be fit for purpose. Assessing the potential uncertainty in core data requires a comprehensive understanding of the measurement methods and test procedures. This presentation describes the workflows and diagnostic tools utilised in a forensic review of an extensive SCAL dataset from a carbonate reservoir in the Middle East. The new field operator had acquired legacy SCAL data carried out by 5 different which varied considerably both in vintage (spanning 2 centuries) and sophistication (in both test techniques and data reporting). Data evaluated included: Archie parameters (m and n), primary drainage capillary pressure (high pressure MICP, centrifuge and porous plate), wettability, and relative permeability tests. A "traffic light system" was used to flag data that could be utilised with some degree of confidence, used with caution, or rejected out of hand.

The majority of the Archie parameter test datasets were rejected due to inappropriate test stress and excess brine effects. The remaining data could only be used with caution due to the potential for non-uniform saturation, stress cycling effects, potential lack of resistivity equilibrium, or unrepresentative test fluids or wettability.

36% of the 486 high pressure MICP primary drainage datasets were eliminated due to unacceptable differences between sample mercury-filled porosity and helium porosity, small pore volumes, and anomalous curve shapes and endpoints. Much of the 20th century centrifuge and porous plate data were rejected due to loss of capillary contact at low pressures (porous plate), or strong suspicions that the data had been fabricated (centrifuge). The remaining data appeared consistent and were carried forward for saturation-height modelling despite lingering uncertainties over the possible lack of capillary equilibrium.

Amott/USBM wettability tests indicated a neutral to slightly oil wet tendency. However, the use of stock tank oil (rather than live oil) for ageing, and the unbalanced Pc used in the forced oil and water imbibition stages, could both have artificially induced a stronger oil wetting condition.

The 20th Century water-oil relative permeability data were rejected due to incorrect wetting (cleaned state tests), non-uniform Sw distribution at Swir, flood instability, and viscous fingering. The 21st century test, performed on composite cores, used more appropriate test conditions and employed more sophisticated test techniques and procedures, but there was still some uncertainty in the reported, measured, and simulated data.

Only around 30% of the extensive SCAL dataset was considered to represent valid or probably valid data that could be used with a reasonable to high degree of confidence in static and dynamic modelling. Approximately 30% of the data were rejected. Uncertainties in the remaining data could be reduced by re-interpretation of the data (where data allow) and by additional test protocols which utilise best practice in SCAL data acquisition and data interpretation.

third release 28 August 2020

AFES Aberdeen Formation Evaluation Society

AFES 2020 Seminar

Core: the most valuable asset in your reservoir

2nd & 9th September 2020 - Virtual Event

Philippe Rabiller – RABILLER Geo-Consulting

Capillary Pressure - An Integrated Flow Chart For Carbonate Reservoir Characterization From Resource Assessment To Field Development And EOR Applications

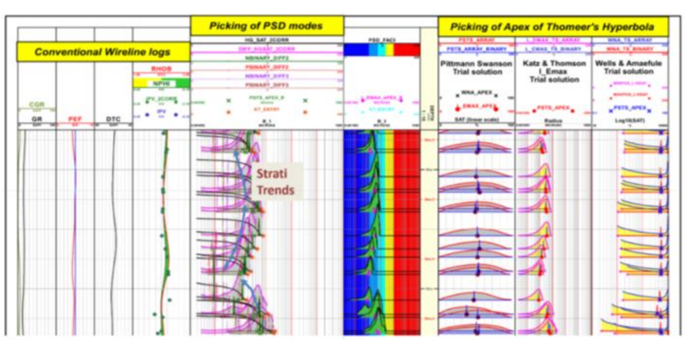
Aiming to improve the characterization of Carbonate Reservoirs from resource assessment to optimization of the static and dynamic modeling, we describe a holistic flowchart for an integrated approach by using the capillary pressure measurements. Its most innovative steps from pore scale to field scale is illustrated on a Super Giant Carbonate Reservoir from the Middle East.

The flowchart relies on patented, published and proven "data driven" algorithmic techniques (k-NN, Histogram Upscaling and MRGC-CFSOM clustering) devoid of any user's bias. Its capability to integrate Static and Dynamic, from Pore Scale to Log scale, stems from the integration, prediction and upscaling at log scale, over cored and un-cored intervals of MICP curves together with all core and log material. Predictions by means of "k-NN multiple modeling" of SCAL & RCA plug measurements allows a reliable and accurate characterization of the rock matrix at log scale, while quantifying its degree of heterogeneity. By revealing to the geoscientists, the pore scale rock texture, its stratigraphic evolution and its heterogeneities, the continuous profile of upscaled Pore Size Distribution (PSD) curves vs logs provides invaluable information on the rock forming processes controlling the matrix Porous Network.

By applying the Purcell theory onto the upscaled PSD, the "Log scale" Permeability and the true FZI and Rmh are computed which are then used as input to a e-Facies model (MRGC-CFSOM) by integrating to other logs and core material. The e-Facies model is interpreted in terms of "matrix" storage and flow parameters as well as in terms of depositional mechanisms and diagenetic overprints, in the light of the core descriptions whose Petrophysical pertinence is thoroughly and quantitatively validated with all the Petrophysical material.

By reversing the method used to derive PSD from MICP saturation curves and using the Pc equating the buoyancy forces at any depth increment, the saturation at any depth increment above the actual Free Water Level (or a scenario of FWL), is computed from the continuous profile of upscaled PSD. Production data, RSTs and PLTS provide the information on total flow and by subtracting matrix contribution to the total flow, the location and quantification of the contribution of the depth intervals with large vugs and fractures is greatly eased, particularly if Borehole imagery is available. The contribution of Matrix, large vugs and fractures are then merged into a single model used for robust well to well correlations, zonation of the reservoir, 3D gridding and volumetric evaluation.

Using this innovative flowchart approach, characterization of high permeability streaks, saturation height function and chemical polymer EOR processes were greatly improved as input to the static and dynamic model history match exercise.



Save, Share, Display, Process, Integrate, Interpret MICP data like any log

AFES 2020 Seminar

Core: the most valuable asset in your reservoir

2nd & 9th September 2020 - Virtual Event

Alan Swanson – Core Laboratories (U.K.) Ltd

Dual Energy CT Scanning – Millimeter-Scale Log for Cored Intervals

Rapid, non-destructive screening using high-definition imaging techniques now provides a viable solution for superior visualization and detailed quantitative core assessment. The scope of the paper includes advancements in capturing high-resolution lithological variations and rock properties, including geomechanical behavior of cores with three-dimensional scanning of cores. This detailed information is available before the cores are removed from the inner core barrel and other measurements are commenced.

X-ray scanners, popularly known as Computed Tomography (CT) scanners are used for such qualitative and quantitative description of cores. Similar to medical applications, CT scanners are used to capture the entire three-dimensional aspect of rocks when they arrive from wellsite. Newer and advanced CT scanners have capabilities to quickly scan objects at more than one energy level. Dual Energy CT scanning of cores provides information on Compton scattering and photoelectric absorption at a millimeter-scale, vertically.

When combined with extensive laboratory physical measurements, high-resolution bulk density and photoelectric factors are calculated. Cluster analysis of these data combined with core databases encompassing global lithotypes, result in an interpretation of core mineralogy and therefore, a mineralogy log for the cored intervals. Availability of vast core data enables robust empirical approach of quantification of strength profile and dynamic mechanical properties at millimeter-scale for the cored intervals. Strength index at such high resolution, in conjunction with CT-based acoustic velocities can help quickly assess and refine lateral landing zones in a well. Additionally, applications of dual energy CT include, detailed fracture description, orientation of cores without physically scribing cores, enhanced sub-sample selection, porosity etc. This information is also used to correct downhole logs where resolution is typically coarser than what are captured with CT scanners.

K. A. Wright and H. Kombrink – North Sea Core

The Second and Not So Secret Life of Core with the North Sea Core Initiative

The North Sea Core initiative is a volunteer-based project, set up in response to the release of core material through the relinquishment, abandonment and decommissioning of fields along the UK Continental Shelf. The initiative started in October 2017, before officially being launched in November 2018, through the use of a dedicated email account, website and a range social media accounts. Founded on the basis that core material provides an incredible resource for understanding the subsurface, the aim of the initiative is to collect and distribute core to the wider geological community.

At the time of writing, core material has been donated from seven companies, ranging from the Carboniferous to the Paleocene across the UKCS. At present, with the range of materials including educational and research supplies, to individual core samples and framed displays, we have supplied over 100 national and international shipments to 12 countries. We are also fortunate to have had our Exploration Boxes, which focus on the petroleum geology of the North Sea, sponsored by the PESGB, the Petroleum Group of the Geological Society and the OGA.

The scale and nature of the requests we receive clearly indicate that the value of core should never be underestimated. Long after the material has been seen to serve its purpose within the exploration sphere, old core can have the potential to answer new questions. It can have a second life in the education of the next generation of geoscientists, help make geology accessible to non-scientists, and aid in research for present and future energy needs. We aim to present how we have successfully been able to facilitate the collection, transformation and distribution of a variety of core material and the clear impact it has had.

third release 28 August 2020

AFES 2020 Seminar

Core: the most valuable asset in your reservoir

2nd & 9th September 2020 - Virtual Event

Chris Reed – Mercat Energy Limited

Integration of Continuous Core Strength Measurements and Rock Mechanics Tests for Optimised Strength Models in Geomechanics Applications

Sand production is a major issue in many reservoirs. Effective sand management requires an understanding of the mechanisms that cause sanding and the development of field-validated geomechanical strength and stress models to predict the critical conditions for sand production. Rock mechanics tests on core provide a direct measurement of rock strength. However, core is discontinuous and test plug coverage is inherently limited, so the strength model is normally based on log indicators calibrated against viable core plug test data. This may be the only opportunity to ground strength models in reality so it is vital that the best use is made of this relatively scarce and expensive resource.

This presentation describes the development of a geomechanical strength model for a potentially sand-prone reservoir comprising a complex sequence of variable grain size sandstones and thin-bedded shaly sands. The lithologies created significant challenges in the acquisition of reliable and representative rock mechanics plug test data and in initial core-log calibration, including sample selection and plug failures. Plug sampling in thin-bedded heterogeneous formations can be a haphazard process leading to understandable bias in sample selection: successful log-based strength models must encapsulate the full dynamic range of rock strength properties.

An enhanced core analysis workflow was developed to optimize geomechanical modelling. This integrates standard rock mechanics core plug tests with continuous and semi-continuous, non-destructive, direct core measurements and wireline log data.

Initial non-destructive Equotip hardness index tests were complemented by an extensive, continuous core scratch testing campaign run on core, including intervals that had suffered extensive plug failures. The scratch tests yielded a continuous profile of Uniaxial Compressive Strength (UCS) and P-wave velocity values which resulted in robust correlations with wireline porosity logs. They were used to map heterogeneity length-scales to guide the selection of representative sample sites for both rock mechanics test (RMT) plugs and SCAL plugs. The sample site selection protocol based on the upscaled scratch test data resulted in fewer plug failures on plug preparation. The RMT plug test results were also found to be in excellent agreement with the scratch strength profile.

The robust multivariate relationship established between the rock strength profile and selected wireline logs enabled reliable upscaling of plug rock properties to predict rock strength in uncored intervals and wells.

The heterogeneity assessment protocols from the scratch tests enable more representative plug site selection and more robust core property-log calibration at different length scales. This can lead to a significant reduction in uncertainty in geomechanics strength models, and better decision making in sand management.

third release 28 August 2020