London Petrophysical Society

Petrophysics for the Energy Transition

Thursday 7th September 2023

Geological Society, Burlington House, London

09:00-17:00 (London GMT+1)

Abstracts

Start Time	End Time	Name	Company	Talk Title
09:15	09:30	Registration		
09:30	09:40	Alina Khmelevskaya	LPS	LPS VP Seminars - Introduction
09:40	10:15	Gabe Lauderdale-Smith	ERCE	Petrophysical Considerations for CO2 Capture and Storage
10:15	10:50	Melissa Johansson	Geode Energy	Geology of Subsurface Fractures– Application to Geothermal and CCS Exploration
10:50	11:25	Geoff Page	Baker Hughes	Monitoring and Appraisal of Carbon Dioxide Saturation from Multi-Detector Pulsed-Neutron Characterization and Modelling
11:25	11:55	Comfort Break		
11:55	12:30	Muhammad Nur Ali Akbar	Prores AS	Dynamic Reservoir Rock Typing for Supercritical CO2-Brine System in Sandstone
12:30	13:05	Rajat Rathore	CGG	Integrated Petrophysics and Rock Physics Workflow for CCS Reservoir Characterisation and Monitoring
13:05	13:40	Bassey Bassey	Cranfield University	Exploring the Barriers to CCUS Implementation in Developing Countries: A Case Study of Nigeria
13:40	14:40	Lunch		
14:40	15:15	Andy Stocks	Natural Hydrogen Study Group	Petrophysical Challenges in the Exploration for Natural Hydrogen
15:15	15:50	Rodney Garrard	Nagra	Subsurface Evaluation for Nuclear Waste Storage
15:50	16:25	Panel Discussion		
16:25	16:40	Jack Willis	LPS	LPS President - Closing Remarks
16:40	Networking Reception in the Library			

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

Petrophysical considerations for CO_2 capture and storage

Gabe Lauderdale-Smith (ERCE)

Carbon Capture Utilisation and Storage (CCUS) encompasses a range of methods and technologies that involves the capture of carbon dioxide (CO_2) from an emission point source and subsequent sequestration via injection into geological formations. Commercial scale CCUS requires an accurate understanding of the subsurface for successful implementation of field development plans. Any CCUS project can be better managed by application and adherence to the CO_2 Storage Resources Management System (SRMS), which aims to develop a consistent approach to estimating Storage resources and Capacity of CO_2 in the subsurface and evaluating development projects.

As the CO_2 storage capacity depends on the physical and chemical properties of the geological formations and their host fluids, Petrophysicists play an important role in the successful deployment of any CCUS project.

This presentation aims to:

1) Outline the key petrophysical considerations for compliance under the CO_2 Storage Resources Management System (SRMS).
2) Highlight key similarities and differences between petrophysical evaluations under the SRMS and traditional evaluations under the PRMS (Petroleum Resources Management System).
3) Outline a generic 'petrophysical checklist' to act as a guide for evaluation, dependent on CCUS project maturity, as well as providing a risk matrix to communicate key subsurface project risks and ways to mitigate these through data acquisition.

Speaker bio

Gabe is a Petrophysicist at ERCE and has 6 years of professional experience in the upstream oil and gas industry. He has worked as a petrophysicist and development geoscientist at a midsized operating company in New Zealand, before joining ERCE.

His experience is varied throughout the E&P project lifecycle, related to development planning and well execution, planning of appraisal data acquisition programmes, specialist petrophysical studies, involvement in Competent Person's Reports as well as Reserves and Resource auditing. This experience spans across conventional and tight gas clastic and carbonate reservoirs, for applications to both traditional oil and gas exploration and development as well as CCUS projects.

Gabe's Interests lie in integrated reservoir characterisation, input into integrated reservoir modelling workstreams and well planning/operations execution.

Geology of Subsurface Fractures – Application to geothermal and CCS Exploration

Johansson, M. Farag, S. Phillips, J. van Doorn , J & Roberts. I

Fractures are present in most rocks and are a result of brittle failure under stress. Fractures are characterised as more or less planar features, whether diffuse and strata bound, clustered in fracture swarms or associated with a fault or fold system. The key descriptive characteristics of a subsurface fracture are the depth, density, strike orientation and aperture. Those fractures with an aperture ranging from micron to centimetre in width are currently beyond the resolution of most subsurface borehole logging tools, however a large data contrast or a tight cluster of fractures can influence the tool readings. These measurements derived from a variety of sources and tool types are acquired through the process of geological, geophysical, drilling, petrophysical and production data acquisition and it is often anomalous data readings that are symptomatic of fractures. In order to identify the geology of fractures in the subsurface, an ensemble of supporting evidence is accrued through the life cycle of a borehole. Advanced measurements and methodologies for fracture characterisation developed for Oil and Gas exploration exist and similar methodology can be applied to the currently developing geothermal and the CCS industry.

Dr. Melissa Johansson acquired her Ph.D. with Prof Dorrik. A.V. Stow from the University of Southampton on 'Deep Water Massive Sandstones. She went on to teach Sedimentology at UNIMAS Borneo for two years at the Faculty of Science before joining Schlumberger in Kuala-Lumpur in 1998. Her career as Principal Geologist spanning 24 years took her around the globe, working in countries such as Malaysia, Brunei, Philippines, Myanmar, Alaska, U.K., Norway, Egypt, Syria, Sudan, Qatar, Yemen and China. Much of her work involved sedimentological and fracture studies, interpreting core, borehole images and integrating petrophysical data in deltaic, shallow marine and deep water sediments as well as fractured basement for both oil& gas and geothermal. In 2015 she started her company Geode-Energy Ltd. a company focussed the Reservoir Characterisation for oil/gas, CCS and Geothermal Fields. As well as retraining in Sustainable energy in 2017 at Cardiff University obtaining a Masters, specialized in Hydroenergy.

Monitoring and Appraisal of Carbon Dioxide Saturation from Multi-Detector Pulsed-Neutron Characterization and Modelling

I. McGlynn, D. Chace, F. Inanc, G. Page, Baker Hughes

The assessment of CO_2 storage capacity and long-term time-lapse monitoring is a fundamental criterion for the management of carbon sequestration projects. Pulsed-neutron logging provides an essential method for measuring multiphase fluid saturations for a baseline assessment of net CO_2 storage capacity, potential rock-fluid interactions, and assessment in depleted gas reservoirs.

Extensive Monte Carlo response modelling has been performed to develop theoretical results for CO_2 saturation. Characterization responses were generated from Monte Carlo N-Particle (MCNP) transport code simulating neutron particles and induced gamma-rays through a three-dimensional representation of materials. Simulations incorporated various conditions including the instrument, wellbore (fluids, tubing, casing, and cement), and the formation (lithology and mineralogy, porosity, and porosity-filled fluid compositions and densities).

Modelling is also used to estimate measurement sensitivities in explicit acquisition conditions, based on specific CCUS storage projects. In one scenario, pressure and density of CO_2 is simulated at full saturation, at increasing pressure and density conditions. In another scenario, CO_2 is simulated as a mixed fluid with CH_4, and with water and residual oil also present. Quantitative gas saturation and differentiation of gas from oil, fresh, or saline water is available using pulsed neutron gamma ray ratio measurements.

The sensitivity of gas saturation measurements relative to the dynamic range of each fluid component, is a function of the composition, concentration, and density of the fluid. Induced gamma-ray count rates are highly affected by the presence of H that moderates neutron propagation. Relative to water and oil liquid phases, the presence of CO_2 can be distinguished from H-bearing fluids (H_2O, CH_4) in capture and inelastic ratio gamma ray responses with greater accuracy.

A key objective is to evaluate the effectiveness of pulsed neutron formation characterization for baseline assessments, and for subsequent monitoring of injected CO_2. Modeling results indicate high sensitivity for CO_2 saturation analysis. This study provides a fundamental characterization required for accurate time-lapse saturation monitoring. A baseline multi-phase formation assessment is critical to evaluate suitability for monitoring CO_2 injection. Post-injection assessment and long-term monitoring is necessary to determine equilibrium and changes in CO_2 pressure and migration.

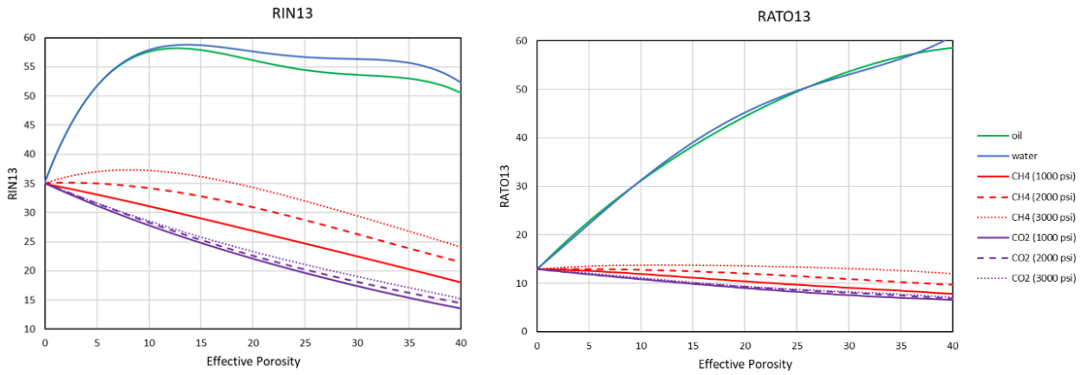


Figure 1. Water, methane, and CO_2 response lines for inelastic and capture ratio models in a sandstone formation. Sensitivity for CO_2 is greater than CH_4 due to the absence of H in CO2 and decrease of H-bearing neutron moderators occupying the porosity.

Geoff Page is the Europe Region Petrophysics Advisor for Baker Hughes, and also provides global support. He graduated in Physics at Imperial College and has now been over 43 years with Baker Hughes, starting as a wireline engineer before also moving into LWD and Petrophysics in general, including 3 years subcontracted into a major oil company as an asset petrophysicist. He has been honoured with the SPWLA Distinguished technical achievement award, is an SPE technical editor, an Honorary teaching fellow at Aberdeen University, and has provided Petrophysics training to over 1500 people.

Dynamic Reservoir Rock Typing for Supercritical CO_2-Brine System in Sandstone

(Muhammad Nur Ali Akbar – PRORES AS)

Dynamic reservoir rock typing is a critical yet infrequently explored aspect of CO2 storage, essential for evaluating flow characterization in dynamic reservoir modeling within aquifer reservoirs. This study introduces a new insight into the establishment of dynamic reservoir rock types for the supercritical CO2-brine system, leveraging relative permeability data.

Our research draws on 22 sandstone core plugs obtained from potential CO_2 storage aquifers in Alberta, Canada, encompassing measurements of relative permeabilities during primary drainage cycle. The rock typing methodology employed incorporates pore geometry and pore structure (PGS), in conjunction with the True Effective Mobility (TEM) function, to comprehensively characterize multi-phase fluid flow properties in rocks. Subsequently, we visualize the outcomes of the rock typing process through 1D and 2D representations, including the simulation of flow characteristics through numerical reservoir simulation.

As a result, four rock groups were established based on pore geometry and pore structure relationships in the studied samples. The critical findings are that the obtained results demonstrate clear groupings of similar TEM-function curves based on relative permeabilities of both brine and CO_2, observed in primary drainage experiment. Additionally, averaged relative permeability curves were derived from the TEM-function and subsequently converted them into conventional relative permeability values for each rock type. Notably, 2D numerical simulations of flow dynamics unveiled unique and contrasting multi-phase fluid behavior within each rock group, particularly evident in saturation profiles over time.

As a novelty, combining PGS rock typing and TEM-function analysis facilitated the effective and efficient grouping of capillary pressure and relative permeability data, ensuring high consistency and minimized overlap in each rock type. Moreover, this approach offers an alternative solution for averaging relative permeability data within each rock type that can greatly reduce the uncertainty of defining relative permeability input and accelerate the process of dynamic reservoir modeling.

Speaker Bio

Muhammad Nur Ali Akbar is an integrated Reservoir Engineer and Petrophysicist with over 8 years of broad international experience in oil and gas field development, exploration, and CCUS (carbon capture, utilization, and storage) projects in Hungary, Croatia, Norway, and Indonesia. Currently, he works at Prores AS, based in Norway, dealing with subsurface digitalization and developing subsurface solutions in the native cloud system. Previously, he was employed by MOL Hungary under the West-Hungarian Field Development Subsurface Team as a reservoir engineer and petrophysicist. He started his career in 2014 as a reservoir engineer consultant at Indonesia R&D Centre of Oil and Gas - LEMIGAS and LAPI ITB, serving various exploration and field development plan projects for Pertamina, Petronas, Repsol, and Ophir.

He holds a BSc in Petroleum Engineering from Bandung Institute of Technology & Science and an MSc in Petroleum Geo-Engineering from the University of Miskolc. He has published and presented more than 20 technical papers, won numerous technical awards from various professional societies, and also served as a technical reviewer in respected scientific and engineering journals. Recently, Akbar was selected as an SPWLA Distinguished Speaker 2022-2023. His research interests for 2022-2023 include the integrated field of naturally fractured basement reservoir characterization, fracture and rock typing, rock physics, and advanced geostatistical methods. He is a member of SPWLA, SPE, and EAGE. Formerly, he served as the president of the SPWLA Indonesia chapter from 2017 to 2019 and led the 2nd SPWLA Asia Pacific Technical Symposium in 2018 in Bogor, Indonesia.

Integrated Petrophysics and Rock Physics workflow for CCS reservoir characterisation and monitoring

Rajat Rathore, CGG

This presentation describes the petrophysical and rock physics workflow in a Carbon Capture and Storage (CCS) screening and monitoring study. The challenges for carrying out such a detailed study often hinge upon the availability of good quality well-data. We often encounter not only the issue of data availability but also inconsistency among various legacy petrophysical interpretations. CGG designed an integrated petrophysics and rock physics workflow for site screening, site characterisation and design of monitoring strategy by linking petrophysical properties (volume of clay, porosity, and fluid) with the elastic attributes (density, velocities) through rock physics models at the well locations. These rock physics models are then applied for post-production and CO2 injection scenarios and then further extended to 3D static and dynamic models, which are the base of geophysical forward modelling for monitoring strategy building (synthetic 3D seismic modelling for example).

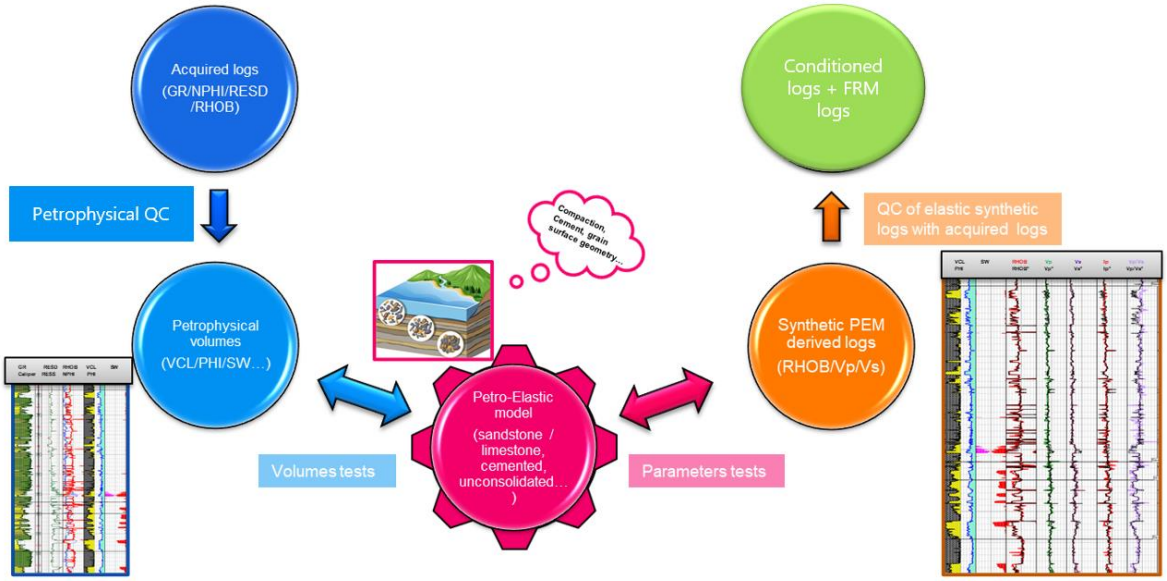


Figure 1: Integrated petrophysics and rock physics modelling workflow for CCS screening and monitoring.

Speaker Bio: Rajat Rathore is the Regional senior Petrophysicist for CGG, where he ensures and advises on the quality of well log before its integration with geological, reservoir engineering and seismic data for projects covering the EAME region. He has accumulated more than 18 years of Oil and Gas industry experience working on various aspects like onsite and remote data acquisition, performing QA/QC and Petrophysical analysis for conventional and unconventional reservoirs, involving rock physics. He received a master's degree in Applied Geology from IIT Roorkee, India in 2005. He is a keen observer of the latest technological advancements in Geoscience and a member of the international association for promoting Geoethics.

Exploring the Barriers to CCUS Implementation in Developing Countries: A Case Study of Nigeria

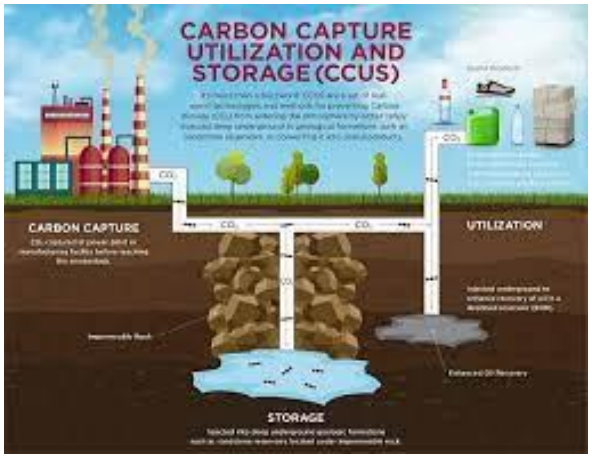
Adedola Betiku[1], Bassey Okon Bassey[2]

[1]School of Energy, Construction and Environment, Coventry University, Coventry, UK

[1]School of Water, Energy and Environment, Cranfield University, Cranfield, UK

Abstract

The global economy has increased CCUS technology development programmes to attain its commercial deployment, which is expected to be beneficial for developing countries such as Nigeria. This paper aims to examine the barriers to CCUS implementation in Nigeria by investigating the differences between global CCUS and Nigerian status, evaluating the perspectives of industry and government practitioners on the economic barriers to CCUS implementation, and identifying policy and industry strategies to deepen the adoption of CCUS. Study participants were selected using a purposive sampling technique to explore the opinions of personnel working in three oil-related agencies: Nigerian National Petroleum Corporation, Ministry of Petroleum Resources and Nigerian Liquefied Natural Gas Limited. Information collected from existing literature and related reports on CCUS were critically analysed, whereas data from semi-structured interviews were generated by audio-recording of participants' responses. These responses were transcribed from audio recordings for each participant and quality controlled by ensuring that transcripts matched the respective responses. Transcripts were analysed using thematic analysis, exploring the research theme using both theory and practice. The theoretical framework utilised PESTEL and SWOT analyses to evaluate the macro environment and the internal and external environment of CCUS implementation in Nigeria. PESTEL analysis showed that CCUS implementation in Nigeria is driven by various regulatory and policy frameworks, lack of adequate capital, public acceptance and infrastructure. Similarly, the SWOT analysis showed that Nigeria has enough coal reserves that could serve as a potential for CCUS implementation. However, Nigeria's weaknesses include lack of expertise in CCUS technology, inadequate capital for CCUS investment and policy summersaults by successive governments. Nigeria should thus consider the introduction of subsidies to mitigate various barriers and challenges that hinder CCUS implementation, e.g., low tax rate for enterprises involved in CCUS implementation. There is also urgent need to improve funding of CCUS implementation through foreign direct investment or by the equity market. Furthermore, the importance for an enhanced technology to deepen the adoption of CCUS in Nigeria cannot be overemphasized as the world moves towards decarbonisation and Net Zero.



Speaker Biography

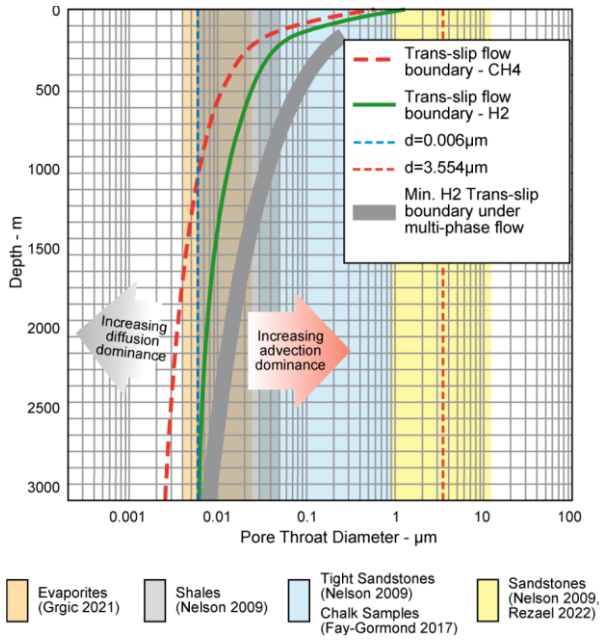
Bassey Bassey is a PhD student of Energy Engineering at Cranfield University, Bedford, United Kingdom. He was previously Assistant Lecturer at Coventry University, Coventry, UK, upon graduation there with an MSc in Petroleum and Environmental Technology. He had worked as an Operations Engineer for Northwest Petroleum and Gas Company Limited; during which he was the research and modification lead. Bassey also holds a BEng in Petroleum Engineering from Federal University of Technology, Owerri, Nigeria. He is an active member of the LPS, Energy Institute, IMechE, SPE and several other professional societies. With over 25 technical papers to his credit; his research interests are engineering sustainability, oil spill prevention, flow assurance and process optimization.

‘Petrophysical Challenges in the Exploration for Natural Hydrogen’

Presented by Andy Stocks, Natural Hydrogen Study Group (NHSG)

Natural hydrogen or ‘Gold Hydrogen’ offers one of the most sustainable energy alternatives to hydrocarbons. Since the accidental discovery of a natural hydrogen accumulation in Mali in 1987 some of the assumptions and concerns relating to the likelihood of such occurrences have been re-assessed and active exploration for other natural hydrogen sources is now intensifying.

The exploration for and appraisal of subsurface hydrogen resources requires many of the technologies and skills that have been developed across all disciplines within the oil and gas industry. Petrophysics is no exception.



1 Pore size influence on diffusive-advective flow regimes

Despite perceptions that hydrogen (H_2) behaves differently to hydrocarbon gases and is difficult to contain, research, mainly focussed on underground storage, is demonstrating many similarities between the two gases. For the petrophysicist this provides some reassurances that some established techniques may be directly applicable. There are however differences in the likely geological settings and lithologies of the source rocks, reservoirs and seals and in how hydrogen may affect some of the common downhole logs. Hydrogen migration and flow can be in gas phase and also in solution through diffusion. Recent research is providing indications of the saturating characteristics of hydrogen gas, through interfacial properties and wettability and new tools are emerging for analysing gases in solution.

The presentation highlights some of the challenges facing the petrophysicst when evaluating data, acquired in hydrogen exploration, from the rock matrix to the pore fluids, and looks at the relationship between gas properties and pore geometry that may determine flow and trapping potential.

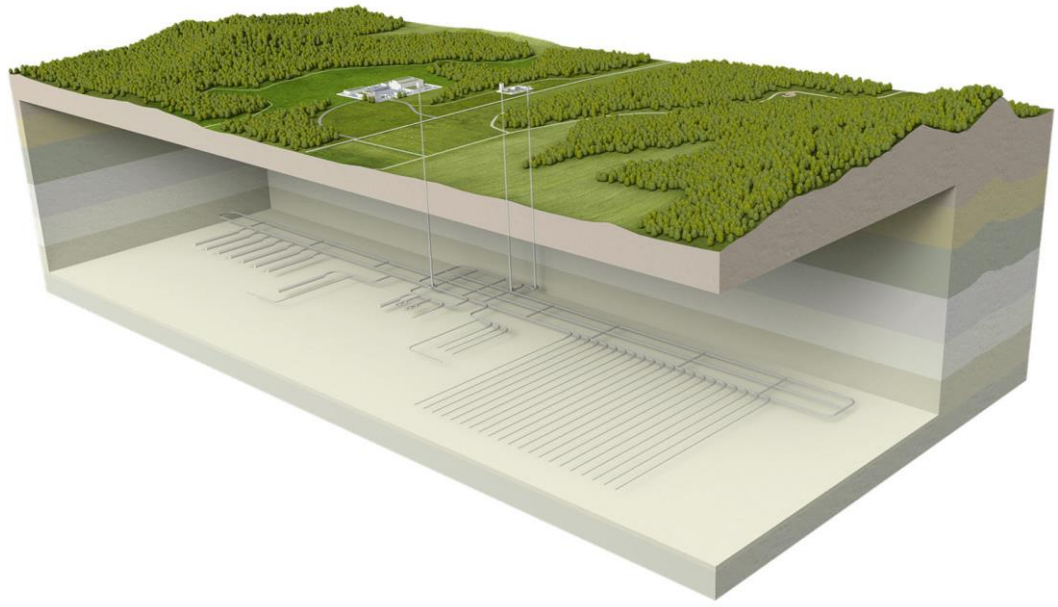
Andy Stocks

Andy is a geologist who has specialised in petrophysics for over 40 years. He worked for an oil major and consulting group before trading as an independent consultant for more than 30 years. He has worked on petroleum exploration, appraisal, development and unitisation projects in Europe, Middle East, Africa, Central America and Asia evaluating clastic, carbonate, volcanic and metamorphic reservoirs. In the minerals sector he has worked on gold mineralisation studies and diamond prospects in southern Africa plus coal projects in South America. He has provided training courses in petrophysics to client companies and, up to 2018, provided the Formation Evaluation module for the Petroleum Geoscience MSc course at Manchester University, UK.

Subsurface Evaluation for Nuclear Waste Storage

Rodney Garrard

The Nationale Genossenschaft für die Lagerung radioaktiver Abfäll (NAGRA) waste management concept foresees the deep geological disposal of radioactive waste in the clay-rich, Mid-Jurassic Opalinus Clay, Switzerland. The safe disposal of radioactive waste requires an accurate characterization of the mineralogy, fluids and structural setting of the host rock and its confining units. The complementary datasets of core and full suite petrophysical logging were an integral component of the data acquisition program and represented a critical input to the overall assessment of the sites by providing direct assessment of mineral content and clay composition (i.e. categorizing the clays into end member types such as kaolinite, smectite, illite and chlorites), quantifying pore volume and provide assessment of the stresses, mechanical properties and identification of possible fractures and faults, and serving as a well-scale tie-in to acquired seismic data.



Credit image: Nagra

Rodney Garrard is a geologist with over 16 years' international experience in the E&P industry. Past duties include Wellsite and Operations Geology at Wintershall, VNG (now Neptune Energy), Det Norsk and Tullow Energy. In 2018, Rodney pivoted into an operations geology-type role for the geological disposal of nuclear waste at the Nationale Genossenschaft für die Lagerung radioaktiver Abfäll (NAGRA) exploration project in Switzerland. Following completion of the data acquisition phase in 2022, Rodney continues with NAGRA in a petrophysics role to execute the data integration phase, making use of his diverse experiences on subsurface projects spanning five continents over the past two decades.

Rodney outlines: "*The last 5 years in rad waste have seen me try to promote the utility of well executed integrated petrophysical workflows by taking the best from conventionally applied methodologies and applying them to the unconventional world*"