AAPG Geosciences Technology Workshops 2022

WORKSHOP BROCHURE

28-30 MARCH 2022 · ABU DHABI, UAE

GEOLOGICAL PROCESS-BASED FORWARD MODELING

WHAT TO EXPECT FROM THE AAPG EXPERIENCE

The American Association of Petroleum Geologists (AAPG) and our suppliers, venues and services partners are committed to providing a clean and safe environment and experience for all our event participants. We remain alert to COVID-19 risks and are closely following and adapting to all applicable health and safety guidelines. While conditions vary between countries, cities, municipalities, and facilities, safeguarding measures you may encounter at AAPG events include physical distancing and masking, readily available hand sanitizer, enhanced cleaning and disinfecting protocols, temperature health checks and screenings, minimized touchpoints and cashless payment options.

As personal safety is a shared responsibility, we ask that all participants ensure that they are feeling well and in good health, with no fever or other symptoms related to COVID-19, before showing up at an AAPG event. Any specific delegate obligations will be published in pre-event communications and clearly displayed on signage throughout our venues. Given the ever-changing nature of the pandemic recovery, registrants will receive regular updates and instructions concerning the latest health and safety requirements.

Please be informed that, as per Abu Dhabi Government Guidelines, all workshop attendees must present a negative PCR test taken within 48 hours of the event and must be double vaccinated.

All attendees must also download the UAE's official COVID-19 app called Al Hosn which must show an 'E' or a star to gain entry.

Please ensure to check travel guidelines for entry into Abu Dhabi **here.**

Please note that AAPG will be regularly monitoring and updating information concerning travel and entry requirements to the workshop.

TECHNICAL PROGRAM COMMITTEE

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WORKSHOP OUTLINE

Today's oil and gas industry is increasingly turning toward complex stratigraphic-diagenetic and structural plays. Prediction and risking of reservoir heterogeneity, seal integrity and source rock sweet spots are becoming more important than ever before. Currently, prediction and risking rely primarily on stochastic geostatistical approaches, which have seen an impressive development over the last few decades. However, exploration of and production from increasingly complex plays has revealed higher levels of uncertainty in geostatistical reservoir models, because of a combination of factors:

- Statistical models do not fully capitalize on the geological information available
- Prediction and risk assessment usually apply a single statistical approach
- Different geostatistical approaches produce varying predictive models
- Surface geological studies (analogues) have proven highly pronounced rock heterogeneity
- Multiple, concurrent processes with various feedback mechanisms control reservoir quality

In order to meet current and future challenges of increasingly complex prospect and play types, the industry needs to develop new, additional approaches to reservoir, seal and source rock prediction. The key requirement for reducing uncertainty and risk in exploration and production is a rigorous understanding and quantification of geological processes and controls.
Fundamental research in geological process-based forward modeling started in the 1960s to 1970s in academia. However, the exploration industry has only recently started to more widely deploy geological process-based forward modeling. The initial focus has been on depositional modeling using diffusion, Navier-Stokes and hybrid geometric approaches, but more recently a diverse range of approaches is being adopted. They include fuzzy logic, cellular automata and various other reduced-complexity modeling approaches that produce output information on petrofacies, depositional environment, and textural porosity. Forward modelling is also being applied to diagenetic processes using reaction-transport modeling (RTM) or reduced complexity proxy rules and to geomechanical processes using finite element or discrete fracture network modeling based on post-burial mechanical stratigraphy and local/regional stress patterns. Geological process-based forward modeling has shown highly promising results for e.g., reservoir quality, seal integrity and sweet spot prediction in complex play and trap settings but many challenges persist, including:

- Calibration of numerical input parameters specific to age, climate and structural settings
- How to use physical experiments and outcrop-reservoir analogue studies for model verification
- Automated input parameter optimization
- Multi-scale process-based models from basin to prospect, play and inter-well scale
- Linking and integrating approaches for depositional, diagenetic and structural modeling
- Integrating textural, diagenetic and fault/fracture-related poroperm models
- Sensitivity analysis and quantitative risk assessment of multiple modeling realizations
- Computational expense vs. complexity of numerical approach vs. temporal-spatial resolution
- Effective implementation in existing industry workflows.

In recent years, interest in geological process-based forward modeling has extended to the geothermal exploration industry and the CO2 storage industry, which face some comparable challenges in predicting subsurface rock parameters and their spatial distribution.
The proposed workshop will include invited experts and interested researchers from both industry and academia. We will concentrate on geological process-based forward modeling rather than on geostatistical modeling, flow simulation, or hydrocarbon systems modeling. Five sessions spread over a period of 2 1/2 days will be dedicated to key challenges in geological process-based forward modeling, finishing with a concluding session to define a practical way forward.

WORKSHOP GUIDELINES

FORMAT
The workshop will be 3 days, consisting of oral presentations, poster presentations and breakout sessions where participants can discuss and investigate a specific theme that is of mutual interest. The first day will feature an inaugural keynote speech by a high-profile professional from the industry.

ATTENDANCE
Registrations are invited from all relevant disciplines with experience and/or knowledge of the subject areas being addressed in the workshop. Registrations will be accepted on a first-come, first-served basis.

CALL FOR POSTERS
You are invited to prepare a poster for presentation at the workshop. If you are interested in participating, please send a short abstract to **cnavarro@aapg.org** by **28 February 2022.** All posters will be produced as pull-up banners and delivered by AAPG. There will not be any other format available for poster display.

REGISTRATION TYPES & FEES
Fees are inclusive of onsite documentation, coffee breaks and luncheons.

AAPG Member*: $1550
AAPG Non-Member: $1750
Join & Save: $1550
Young Professional**: $850
Academia: $500
Student: $350

To register, please visit: midleeast.aapg.org

*To avail the Member rate you must be an active member of AAPG.
**To register as a Young Professional you must be under the age of 35 with less than 10 years of work experience.

REGISTRATION DEADLINE
To guarantee your seat, please make sure to register by **28 February 2022.**

CANCELLATION POLICY
AAPG will refund the tuition, less a $100 processing fee, if the request is received no later than 30 days prior to the workshop. Cancellations must be made in writing. The registrar will accept cancellation notices by telephone, but all such notices must be followed up by fax or e-mail. No refund will be made for cancellations received less than 30 days prior to a workshop being given. Nonpayment of tuition does not constitute automatic cancellation. If no cancellation notice is received by 30 days prior to a workshop, participants are liable for full tuition. AAPG reserves the right to cancel a workshop if enrollment is insufficient to ensure proper effectiveness. Substitutions for individuals can be made at any time. A paid enrollment may be transferred one time to a future workshop if the request is received prior to the 30-day cut-off date.

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SESSIONS DESCRIPTIONS

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DAY 1 MONDAY 28TH MARCH

SESSION 1: CURRENT APPLICATIONS, LESSONS LEARNED AND CHALLENGES

Geological Process-Based Forward Modeling (GPFM) is defined by its forward-in-time calculating component. Modeling starts from a initial condition in the geological past and proceeds to a subsequent condition in the younger geological past or until present times. While forward models may be inverted, they fundamentally differ from inverse modeling approaches like geostatistical modeling that rely entirely on static realizations, e.g. based on variograms.

The foundations for GPFM were laid in the 1960s to 1970s but limited to 1D and simple 2D. Since the late 1980s, GPFM has progressed towards advanced 2D and 3D. Key drivers for this development come from both industry and academia. Interest by industry stems primarily from the objective of predicting reservoir quality and of a quantitative understanding of depositional heterogeneity. Interest by academia originated primarily from the objective to develop genetic, quantitative geological models from descriptive or qualitative data. GPFM also serves as an approach to test existing concepts of deposition, transport and erosion. Predicting future environments from changes in eustatic sea level, sediment distribution and coastal morphology constitute a further important application. However, existing challenges in GPFM have limited its application especially in industry, whether as complimentary approach or as a partial replacement for geostatistical approaches.

The intention of the opening session is to set the framework for the workshop by covering developments in GPFM during the last few years, lessons learned from applications in various fields, discussing reasons for success (and failure) until now and by providing a general outlook on challenges existing today.

SESSION 2: MULTI-SCALE CALIBRATION OF GEOLOGICAL PROCESSES

The benefit of any modeling approach depends on the best possible calibration of input parameters. This fundamental requirement is especially valid for geological modeling because of the inherent complexity of systems, the number of processes involved and the dependency of input parameters from temporal and spatial scaling. A specific challenge is the requirement for parameter calibration in the geological past, i.e., differentiated by specific time intervals and processed to rates of change. This is in marked contrast to parameter calibration in geostatistical modeling, which relies entirely on direct measurements from well locations, seismic data or outcrops.

The workshop intends to cover a wide range of approaches to calibrate depositional, diagenetic and geomechanical parameters. Modern environments and outcrop-subsurface analogues allow e.g., parameter calibration for depositional geometries, transport velocities from sedimentary structures, the degree of compaction and for depositional vs. diagenetic heterogeneities at both high vertical and lateral resolution. The calibration of diagenetic processes and parameters at sample scale predominantly relies on petrographic, cathodo-luminescence, fluid-inclusion, trace element chemistry, $\delta^{13}C$, $\delta^{18}O$ and clumped isotope geochemistry data. Core flooding experiments provide e.g. rates of dolomitization and calcite cementation. 3D stratigraphic architecture in combination with local-regional stress data, burial history and results from e.g. Linear Variable Differential Transducer (LVDT) experiments provide direct input to geomechanical modeling.

An assessment of the limitations of modeling results represents an important part of geological parameter calibration. Multiple realizations from parameter sets with minimum/maximum values or serial variations in parameters are one of several approaches to define acceptable levels of calibration in de-risking elements of petroleum, geothermal and CO2 storage systems.

DAY 2 TUESDAY 29TH MARCH

SESSION 3: MODELING APPROACHES AND APPLICATIONS

The session intends to address and discuss numerical approaches in GPFM. Diffusion modeling has been widely applied for depositional processes because of its balance between complexity and computational expense. Challenges exist in defining diffusion coefficients for various sediment types and in modeling the transport of multiple grain size classes. Navier-Stokes or hydraulic modeling allows detailed flow and transport modeling at high-resolution although simplifications and approximations are required as equations are non-linear for four independent key variables. However, hydraulic modeling approaches are computationally intensive. Fuzzy Logic modeling approaches offer an extension to Boolean logic and are able to handle only partially constrained data and parameters by defining a combined degree of "truth". The advantage is computational efficiency at the cost of resolution and predictive capability. Geometric/volumetric modeling honors mass balance, energy conservation and sediment accumulation equilibrium. It combines computational efficiency and alignment with sequence stratigraphic concepts. Geometric modeling programs are mainly 2D with 3D in development. Mixed or Hybrid modeling approaches, e.g. combining GPFM with geostatistical modeling or Machine Learning/Deep-Learning (e.g. physics-based Machine Learning) represent a recent technology development. Key drivers are assisted parameter calibration, improved resolution of forward models and increased match between models and well data.

Current clastic diagenetic modeling follows either a rule-based approach or focuses on burial depth, temperature and rock texture-related parameters to model the cementation kinetics of quartz and illite. The relatively most widespread approaches to carbonate diagenetic are either rule-based modeling or Reaction-Transport Modeling (RTM). RTM covers a comprehensive set of physical-chemical parameters and processes with high predictive capability for porosity. However, computational requirements are high and, with sufficient resolution, areas of interest do not exceed the field to prospect scale. Geomechanical modeling of stress-/strain distribution, fracture and fragmentation most commonly relies on Finite and Discrete Element Modeling. Input parameters include gravitational, lithostatic and hydrostatic loads as well as pore pressure and temperature. Today, GPFM usually runs on high-performance workstations. Few software packages offer full multi-processor support and high-performance computing (HPC) technology for multi-node clusters is rare to completely missing.

The workshop aims to cover a wide range of GPFM approaches which include the defining forward-in-time calculation component including methodologies for calibration, verification and uncertainty analysis.

SESSION 4: INTEGRATION OF MULTIPLE GEOLOGICAL PROCESSES AND APPROACHES

Current GPFM approaches and studies focus on individual subgroups of geological processes, e.g. depositional, diagenetic or geomechanical processes. However, the full predictive power of GPFM will only be achieved when individual modeling approaches can be linked and integrated.

Examples for challenges in integration include: i) incompatible numerical modeling approaches; ii) temporal and spatial dependencies between key geological processes must be honored; iii) connections to/from public domain or industry databases are required because of data volumes across individual modeling approaches.

For instance, the integration of depositional and diagenetic forward modeling is essential for industry. Porosities derived from depositional modeling reflect textural ("matrix") porosities from grain size distribution and physical compaction. However, they do not reflect current subsurface porosities after diagenetic overprint at shallow to deep burial depths. The majority of diagenetic overprint in clastic rocks occurs at medium to deep burial depths and, with considerable simplification, may be numerically modeled for a stratigraphic interval at its current burial depth only. However, diagenetic overprint in carbonate rocks starts at deposition (at geologic time scales), tends to peak in shallow burial depths and may re-occur at deeper burial depths. As a result, any comprehensive numerical modeling approach capable of predicting current subsurface porosities will have to follow a process timeline of concurrent deposition, compaction, cementation, solution etc. While the temporal interdependency of other processes differs, similar challenges exist for integrating depositional-diagenetic and geomechanical processes. Very few existing studies have tried to link different geological processes and modeling approaches, e.g. diffusion-based depositional and RTM-based diagenetic modeling. Efforts have also been made to combine process-based and geostatistical modeling for various purposes, whether to increase the resolution of process-based models or to address challenges in matching well data.

DAY 3 WEDNESDAY 30TH MARCH

SESSION 5: CASE STUDIES AND APPLICATIONS

The session envisions to include a wide range of case studies and applications from industry, consulting and academia. The best strategy for the implementation of GPFM in all three realms are proven success stories with measurable benefit to operations, whether in oil & gas exploration and production, geothermal exploration and CO2 storage or in research. Because of its importance, this session will cover most of day 3 of the workshop and will be subdivided in two sub-sessions:

5.1 Siliciclastic and Mixed Systems

5.2 Carbonate and Evaporite Systems

Examples for applied studies from industry and consulting include but are by no means limited to: i) prediction of depositional environments (GDE maps) for reservoir, source and seal units; ii) sedimentary architecture and heterogeneity; iii) prediction and identification of stratigraphic-diagenetic traps; iv) rock physics; v) geomechanics and fractured/tight reservoirs; vi) porosity and permeability prediction at inter-well to basin scale; vii) prediction of organic matter for conventional and unconventional systems; viii) input to 3D hydrocarbon system and basin models; ix) geological evaluation of depleted reservoirs for CO2 storage; x) geothermal exploration, especially for Enhanced Geothermal Systems (EGS); xi) benchmarking GPFM modeling vs. geostatistical predictions in operations and, xii) successes (and failures) of GPFM models.

Examples for studies with a fundamental or applied research background include but are by no means limited to: i) sedimentary basins as archives for depositional, environmental and structural processes; ii) reconstruction of subsidence/uplift, eustatic sea-level, sediment input/production and erosion histories; iii) prediction of future environments due to changes in sea-level, erosion, sediment input, coastal morphology and current dynamics; iv) testing geological observations from surface and subsurface data for controlling processes and advanced sequence stratigraphy concepts.

SESSION 6: PERSPECTIVES AND WAY FORWARD

Advanced development of Geological Process-Based Forward Modeling and implementation in standard workflows will be a long-term effort best approached in a step-wise fashion and, as much as possible, in collaboration between industry and academia.

The final session of the workshop will try to: i) summarize learnings and conclusions from the five sessions and related break away meetings; ii) suggest most promising directions in future development of GPFM; iii) serve as opportunity to initiate future research and development collaboration between participants.

TO REGISTER, PLEASE CLICK **HERE**