Core Analysis
Subsurface Technologies
PTA/RTA

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Roberto Aguilera

- Professor of petroleum engineering at the University of Calgary
- 2021 recipient of the international SPE Reservoir Description and Dynamics Award
- 2019 recipient of the international SPE Distinguished Achievement Award for Petroleum Engineering Faculty
- SPE Distinguished Lecturer for the 2000-2001 season discussing Naturally Fractured Reservoirs
- Past Executive Editor of the SPE Journal
- BSc, Universidad de America, MEng and PhD, Colorado School of Mines, all in petroleum engineering

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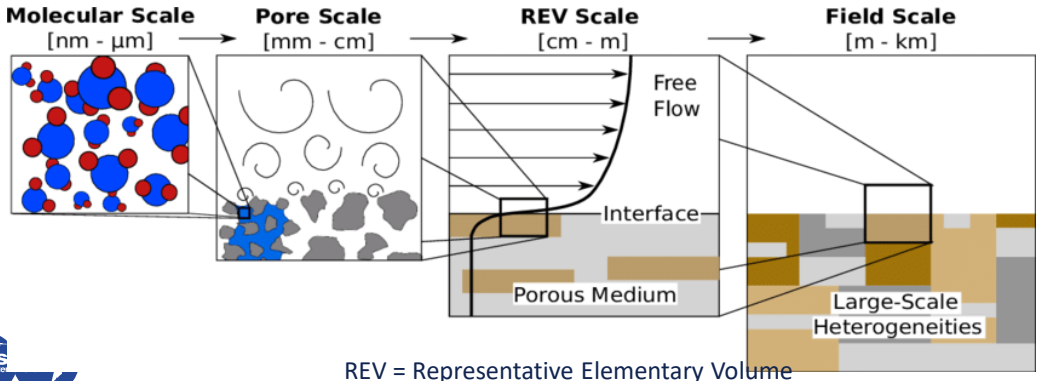
Molecular, Pore, REV and Field Scale (Present)

A good understanding of "scale" is key in formation evaluation and beyond, e.g., we can move to the scale of the petroleum system



REV = Representative Elementary Volume
Source: Mosthaf et al. (2014)

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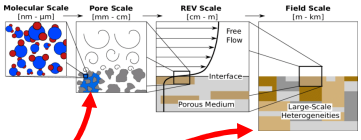
Molecular, Pore, REV and Field Scale (Present)

- Unconventional reservoirs with small pores and pore throat apertures present very unique challenges (molecular scale to be discussed next in this webinar by Dr. Y. Akkutlu)
- In general, our industry has good experience with the pore and field scales. We perform geomodeling and conventional reservoir simulation with a reasonable level of success.



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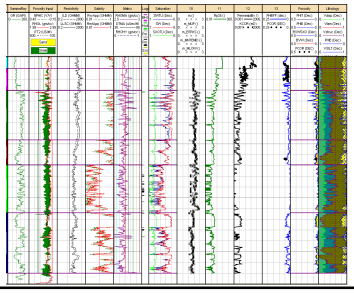
Formation Evaluation / Reservoir Characterization

- Core Analysis (and well logs)
- Subsurface Technologies
- PTA / RTA

Conventional and unconventional (tight and shale reservoirs)



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Core Analysis (and well logs) (Present)

plug

Cuttings
Hews

- Cores are **direct sources of information** (drill cuttings also)
- Basic rock properties (e.g., porosity, permeability, fluid saturations)
- Special core analysis (SCAL) (e.g., relative perms, cap pressure, electrical properties, NMR, geochemistry, geomechanics, unconventionals, **EOR to be discussed at the field scale in this webinar by Vinay Sahni**)
- CT scan (e.g., visualize and analyze the internal anatomy of the rock)
- Digital rock characterization (e.g., visualize and evaluate pore system, permanent preservation of core samples)
- Under favorable conditions, estimate some of the above properties from **drill cuttings** (e.g., porosity, permeability, geochemistry, and back-calculate some geomechanical properties)
- Cores are excellent for calibrating well logs (**indirect sources of information**)

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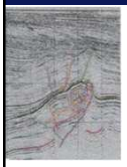
Core Analysis (and well logs) (Challenges)



Mattner

- **Upscale**: Acoustic logs to seismic velocities and pore-scale attributes to core, wellbore and field scales (S. Perry)
- Improve **visualization** of multi-phase fluid mobility phenomena on a pore scale (C. Lindsay)
- Improve **petrophysical models** for reservoirs with multiple porosities (e.g., interparticle, fractured, organic…)

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Core Analysis (and well logs) (A Look Ahead)

- Develop technology for rock mechanics measurements to physically measure all stress tensors (S. Perry)
- Continuous innovation and improvement in the quality of micro-resistivity and sonic images and digital rock characterization.
- Innovate to extend hydrocarbon knowledge into CO2 capture, utilization and storage (CCUS) and geothermal energy (C. Lindsay)
- And extend it even more by characterizing shale reservoirs, to improve oil recovery via utilization of H&P CO2 injection, and storage of CO2 in the shale oil reservoir (CCUS), upon completion of the H&P project

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Subsurface Technologies (Present)

M.Proett

- **Formation Testing**: Cut formation testing time in half and generate ten times the data. This includes conventional and low permeability reservoirs, maybe shales (M. Proett, 2022)
- Using **probes** of different shapes can enhance pretesting capabilities, e.g., pore pressure, fluid composition, mobility, permeability, skin, anisotropy (kv/kh), dip angle, azimuthal orientation & heterogeneities.

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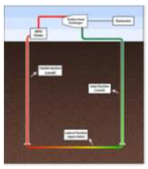
Subsurface Technologies (Challenges)



Van Oort

Geothermal: Synergies and differences between the hydrocarbon and geothermal wells are important. An opportunity assessment and management framework have been proposed by Livescu and Dindoruk (2022) to improve the outcomes of diverse geothermal hydrocarbon projects

- Data management is critical in the “trend toward tighter integration and data sharing between drilling-and-completions applications and other disciplines applications such as subsurface” (Sawaryn et al., 2015)

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Subsurface Technologies (A Look Ahead)

M.Proett

- A method with **new probe designs** in formation testing could improve the sensitivity to anisotropy (M. Proett, 2022)
- Similarly, the method could succeed in the the evaluation of **shale reservoirs**
- Study the time-dependence of the subsurface temperature due to the heat exchange between the fluid flowing through the **closed-loop** system and the surrounding formation in geothermal projects (Livescu and Dindoruk, 2022).

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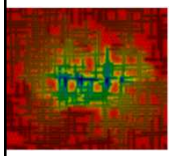
PTA / RTA (Present)



V. Artus

PTA / RTA principles and methodology are for the most part mature and remain approximately the same. Recent advances mostly due to **tools and technologies** including downhole gauges, flowmeters, software (V. Artus)

- Basic methodology based on **linear diffusion**. Non-linear behaviors are linearized with pseudo functions, or are fully reproduced with numerical models …but analyzed via diagnostic plots for linear diffusion
- **Numerical models** are now fully part of the RTA toolbox

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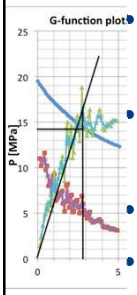
PTA / RTA (Challenges)



- PTA: Address heterogeneity of unconventional plays. Introduce discrete fracture models, anomalous diffusion… (V. Artus)
- PTA: No consensus on the most appropriate methodology for minifracture (DFIT) analysis
- PTA: Limited radius of investigation
- RTA: Production decline of one, tens, hundreds or thousands of wells interpreted using DCA, with emphasis on history match and decline trends without taking into account the underlying physics. **Fast method but delicate**, leading to very optimistic forecasts, if the DCA is performed during transient flow periods

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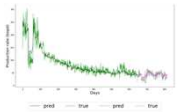
PTA / RTA (A Look Ahead)

- Continuous **innovation on tools and technologies** including downhole gauges, flowmeters, software (V. Artus)
- Reach consensus on usage of **numerical models for PTA**
- Reach agreement on procedures for analysis of **multi-well data and multiphase data**
- Integrate **geomechanical effects** that are mostly ignored by conventional RTA approaches
- Placing emphasis on **physics of petroleum reservoirs** will become a standard while developing ML/AI methods (**hybrid methods**). Not doing so might lead to horrible fiascos.



Aranguren

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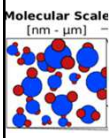
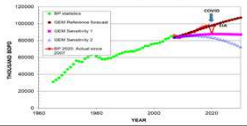
Comments / Conclusions



- In general, we are in good shape at **present** for characterization of conventional oil and gas reservoirs thought formation evaluation (FE) using core data, well logs, subsurface technologies and PTA / RTA.
- There are important **challenges** in all-of-the above FE areas, particularly at the molecular scale but probably they will become manageable in the not-too-distant future.
- FE will help in the **future** development of technology addressing CCUS, H2 storage and geothermal energy needs.
- FE will help to increase production / recoveries of oil and gas in conventional and unconventional reservoirs for meeting the **future** world demand that will continue increasing over the next few decades. This will be done keeping a close eye on economics and externalities (EE). **Bernadette Johnson will discuss the Reservoir Management aspects of this webinar.**



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THANK YOU

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