



SPWLA SAUDI ARABIA CHAPTER (SAC) 9th Topical Workshop

CORING AND CORE ANALYSIS: CHALLENGES AND BEST PRACTICES

Virtual Workshop Series (Feb, Mar & Apr 2021)

The Basics of Reservoir Fluid Sampling and Analysis

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March 2021



STRATUM
RESERVOIR

Agenda



- 1 Role of Fluid Properties in the Oil and Gas Industry
- 2 Overview of Reservoir Fluid Modeling
- 3 Overview of Reservoir Fluid Property Measurements
- 4 Overview Reservoir Fluid Sampling

Oil and Gas Companies, Find, Produce and Sell “Fluids”

Find and Assess
Oil and Gas Field
Economics

Develop and Produce
Oil and Gas Fields

Transport
and Trade
Oil and Gas

Manufacture
Fuel and
Products

Market
Fuels and
Products

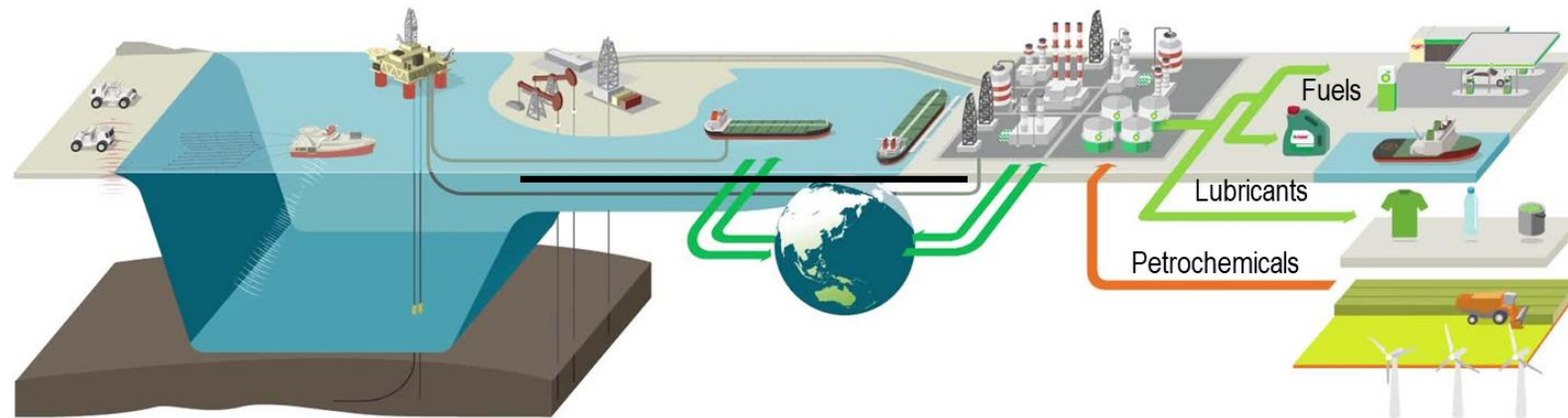
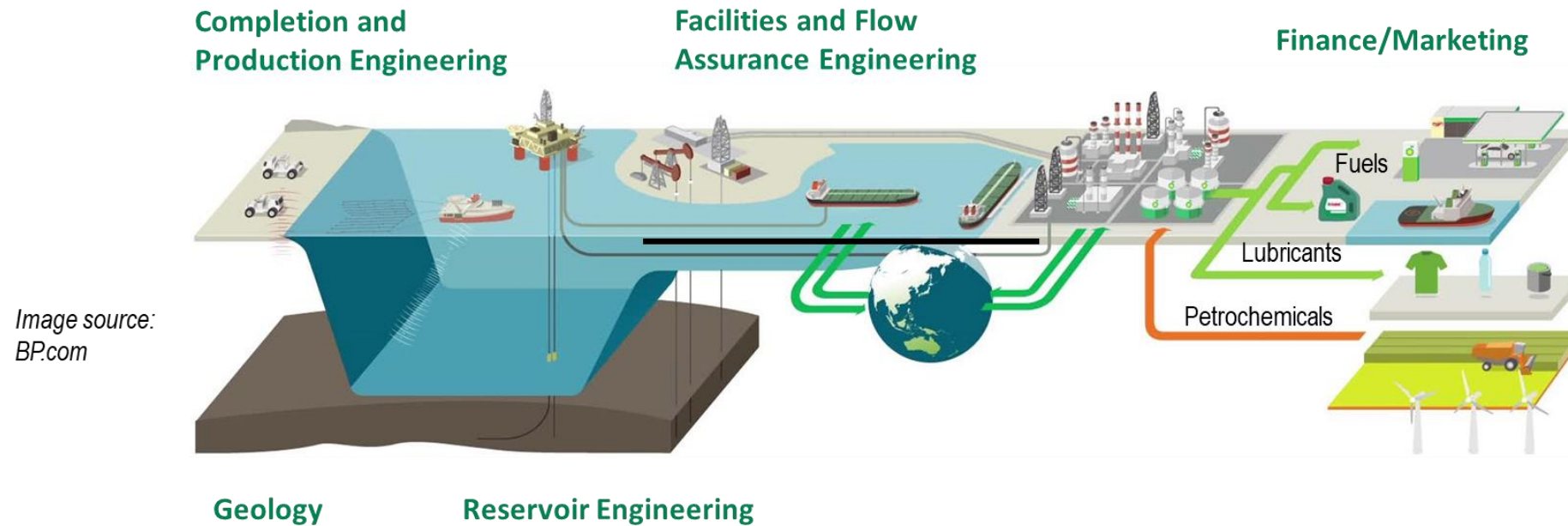
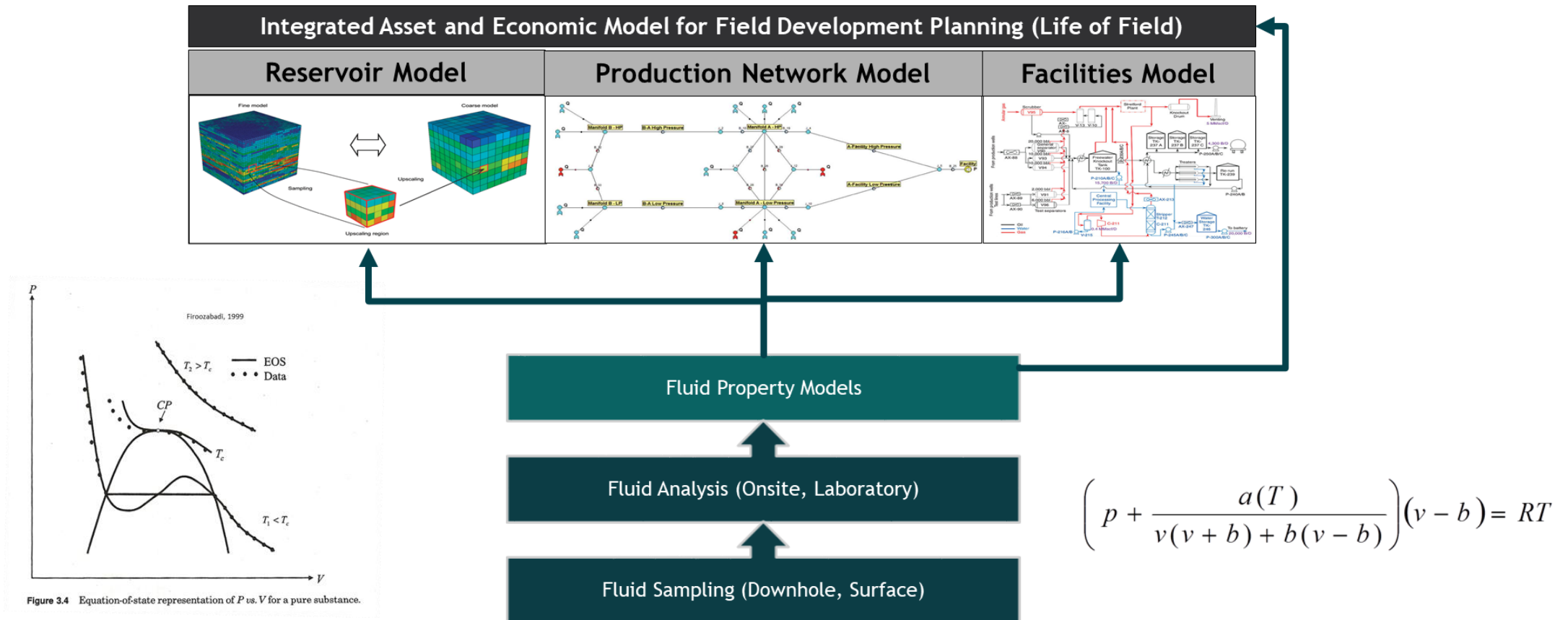


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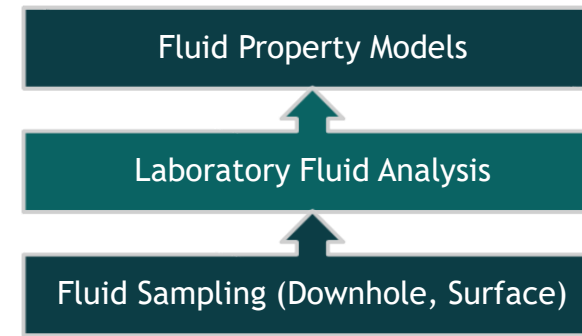
Fluid Property Data is Required for Many Workflows



Fluid Properties Input to Integrated Asset Modelling



Fluid Analysis Requirements



1

Pressure-Volume-Temperature (PVT) Characterization

Extended carbon number composition
Reservoir AND surface volumetric properties
Saturation pressure, Viscosity, Density

2

Flow Assurance Fluid Characterization

Wax, asphaltenes, scale, hydrates, corrosion

3

Gas Miscible EOR

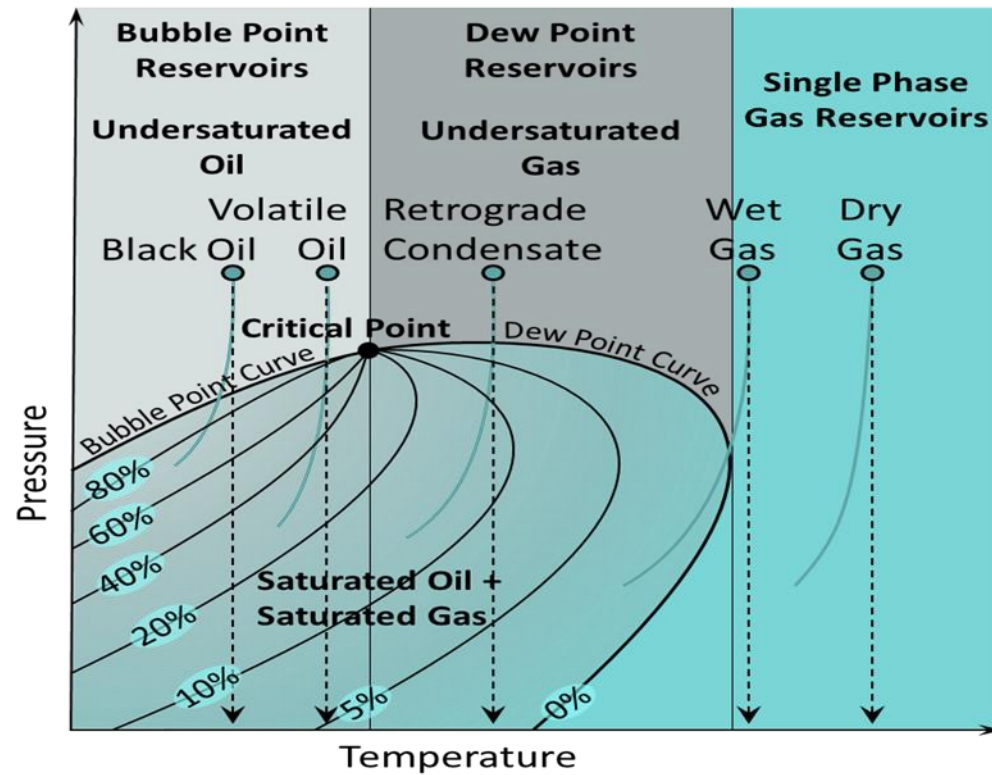
Conventional and unconventional
Reservoir Fluid - Injection Gas phase behavior

4

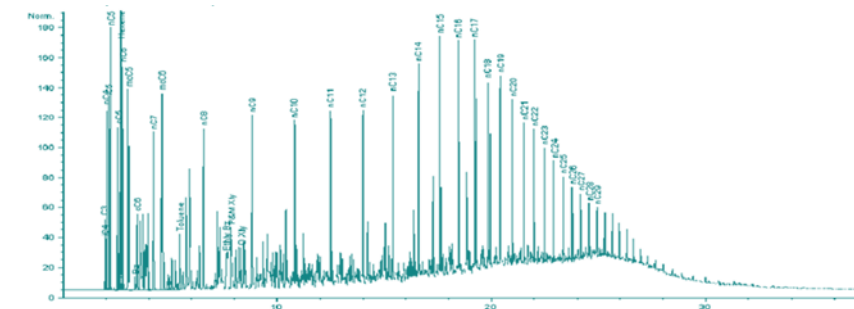
Production

Production Allocation - line condition PVT
Composition change vs time - trace elements

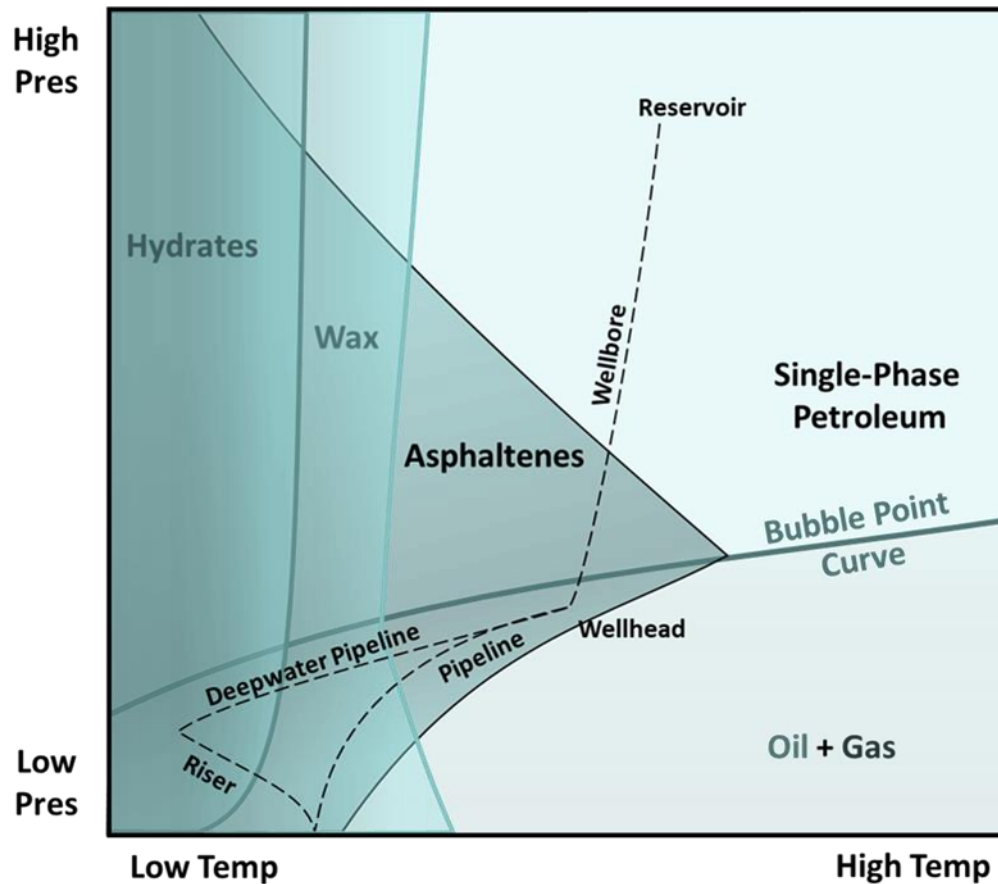
Reservoir Fluid PVT Behavior and Composition



	Dry Gas	Wet Gas	Gas Condensate	Volatile Oil	Black Oil
N2	0.3	0.2	3.68	1.21	0.36
CO2	1.1	2.1	1.28	2.10	0.29
C1	90.0	85.0	85.2	60.50	23.97
C2	4.9	4.7	5.36	7.75	6.42
C3	1.7	3.2	1.75	4.75	7.64
i-C4	0.6	1.2	0.36	2.27	1.79
n-C4	0.5	1.0	0.46	2.01	5.29
i-C5	0.3	0.9	0.19	1.96	2.98
n-C5	0.2	0.8	0.16	0.88	3.27
C6	0.2	0.3	0.22	1.90	4.85
C7	+0.2	+0.6	0.39	2.51	7.09
C8			0.44	2.45	7.67
C9			0.20	1.68	5.19
C10			0.12	1.45	4.47
C11			0.06	1.05	2.96
C12+			0.15	5.53	15.76



Fluid Properties for Production Simulation Workflows (Flow Assurance)



Inorganic Scale



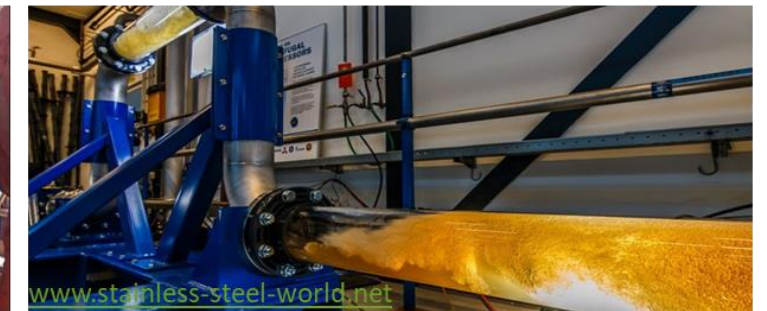
Asphaltenes



Wax

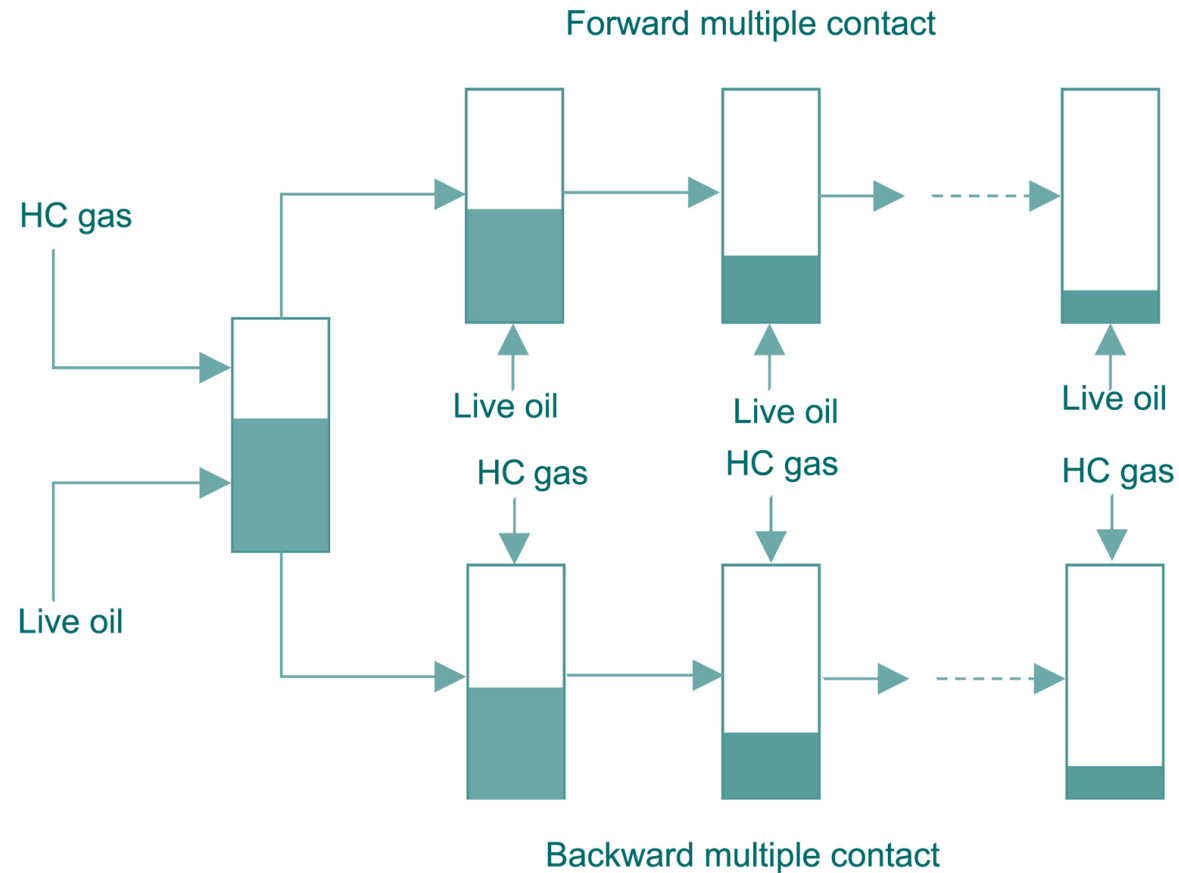


Gas Hydrate



Multiphase Flow

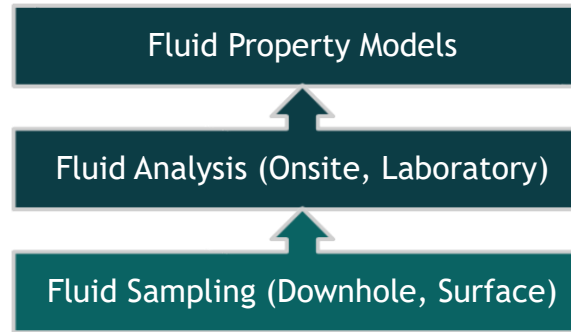
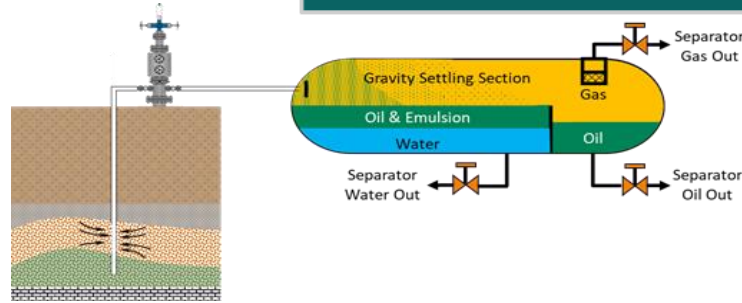
Gas Miscible EOR - Miscibility Mechanisms



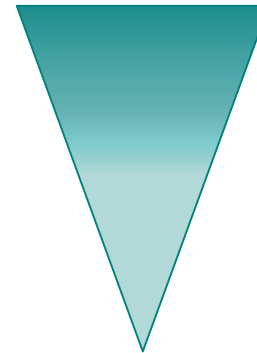
<https://onlinelibrary.wiley.com/doi/abs/10.1002/apj.2286>

Factors Influencing the Quality of Sampling Operations

- Reservoir conditions
- Well conditions
- Fluid type
- Sampling methods, equipment and operating procedures
 - Competency of field engineers
 - On-site transfer
 - On-site measurements/methods
 - Laboratory practices
 - Calibration of instruments
 - Quality of analytical equipment



SEVERITY



‘Bad’ sample = ‘bad’ results (irrespective of lab quality, people)

Reservoir Fluid Sampling Operations

Exploration, Appraisal, and Development Wells

Sampling Conveyance Method Options

1. Drilling Mud

Surface Mud Gas Logging

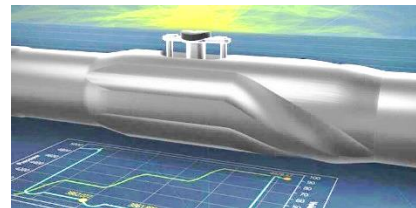
- Gas Extraction
- Sampling for on-site analysis
- Depth and type of hydrocarbon
- IsoTube sampling



2. Drill String

Downhole Formation Testing While Drilling

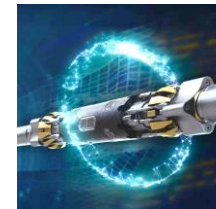
- Done while tripping
- Open Hole sampling probe
- Depth set by mud gas logging and LWD data
- Single Phase/Standard Samples
- Downhole Fluid Analysis



3. Open Hole Wireline

Downhole Formation Testing

- Open Hole Sample probe(s)
- Depth set by mud gas logging, LWD, and open hole logs
- Single Phase/Standard Samples
- Downhole Fluid Analysis



4. DST String (Cased Hole)

Well Testing Operations

- Downhole sample carrier
- Single Phase/Standard Samples
- Limited Telemetry

Surface Separator Sampling

- Stable producing GOR
- Separator gas/oil samples
- Laboratory Recombination



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Reservoir Fluid Sampling Operations

Exploration, Appraisal, and Development Wells



1. Bottomhole Sampling

- Slickline, Wireline, coiled tubing conveyed
- Conventional or single phase
- Well producing (lowest possible rate) or shut-in
- Surface sample restoration and transfer to shipping bottles
- Relatively low volume
 - 600 cm³ per sampler

2. Wellhead Surface

- Cheapest option if fluid single phase or oil/water at wellhead P&T

- Upstream of choke

Subsea

- ROV conveyed to subsea wellhead sampling interface
 - Often on flow meter
- Remote tap of wellhead
 - Downstream of choke
- Always two/three phase
- Isothermal/Isobaric pumpout loop
- Phase separation and isolation
 - Not phase flow fraction representative
- Wellhead isolation and control system via ROV and tree.

3. Flowline Isokinetic

- Mist flow downstream of the choke
 - Gas condensate production
- Sample probe traverses the flowline
- Extract volumetric fractions at “isokinetic” conditions into benchtop scale separation system
 - actually 0 Δp at probe entry

Flow Meter

- Direct multiphase extraction
- Phase separation and isolation
- Not phase flow fraction representative

4. Surface Separator Production Well Testing Operations

- Sometimes required by regulatory bodies
 - TRC, ERCB
- If $p_{res} < p_{sat}$ $GOR > R_{si}$ and will NOT get a representative sample from GOR recombination
- Recombine to P_{res} and push off gas
- For unconventional wells, sample as early as possible

Permanent Production Separator

- Often multi-wells commingled

Summary

1. Fluid Properties models are required to simulate reservoir, production network, and downstream refining operations and the workflows they support
2. Sufficient fluid property data must be measured to adequately tune the fluid models
3. Representative reservoir fluid sampling is the foundation for the whole work

Bad sampling or bad analysis negates good model development with potentially serious economic consequences

Thank You



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