[PS]Turning Rocks into Oil: Understanding Fluid GOR and API without any Fluid*

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Abstract

From an exploration or development step-out perspective, Black Oil (GOR ~200 – 1,750) and Volatile Oil (GOR ~ 1,750 – 4,000) are often the more profitable unconventional play objectives. In the past, we have relied primarily on thermal maturation proxies to constrain our fluid windows during basin evaluation when we do not have fluid information. Because all source rock kerogen conversion kinetics differ to some degree, thermal maturation provides a rough, but useful guide to the type of fluid generated. Ideally, one would like to have fluid PVT data to build an equation of state model, and thus map fluid properties over a frontier basin, but such data only exists in areas that have already been drilled or developed. It is typically not available when exploring frontier or under-explored basins/sub-basins. We have leveraged PVT data collected from numerous unconventional source rock plays and found strong relationships between fluid composition GORsat. Moreover, there are strong relationships between GORsat and saturation pressure, oil viscosity, formation volume factor at Psat, and oil API gravity. Therefore, if one could develop a means of estimating GORsat from source rock, we would be able to estimate fluid composition and develop an analogous equation of state to map fluid properties across unconventional target areas of interest.

We report here a means estimating fluid GORsat when we have no fluid, from rocks, via extracted rock pyrolysis gas chromatography. The methodology was validated using both core and cuttings source rock pyrolytic data from the same wells, or from wells adjacent to, the PVT fluid wells in our PVT database. As noted, the PVT database shows strong relationships between GORsat and some compositional ratios. We can use the same compositional ratio data generated from rocks via pyrolysis GC to build a relationship that mimics the PVT database relationship to estimate GORsat without having any fluid. The resulting fluid-type estimation can be tied to other independent data from rocks alone, such as kerogen kinetic maturation assessments. We will show examples of the technique's validation and application. The key take-aways are: (1) We can determine fluid type, without fluid, from solvent extracted source rock, and (2) This assists us in mapping fluid types where no produced fluid data are available.

Turning Rocks into Oil: Understanding fluid GOR and API gravity without any fluid

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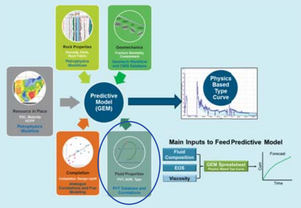
Background: Fluid characterization for exploration



Components to a physics based type curve prediction for exploration: This poster will focus on fluid property characterization when we have no fluid.

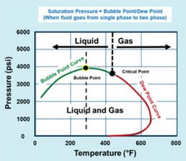
Encana Fluid Classification Parameters

Reservoir Fluid Classification	Code	Gas/Oil Ratio (scf/STB)	Liquid Yield Ratio (bbls/mmcf)
Heavy Oil	HO	< 200	>5,000
Black Oil	BO	200 - 1,750	572 - 5,000
Volatile Oil	VO	1,750 - 4,000	250 - 572
Very Rich Gas Condensate	VRGC	4,000 - 6,667	150-250
Rich Gas condensate	RGC	6,667 - 20,000	50-150
Gas Condensate	GC	20,000 - 50,000	20-50
Wet Gas	WG	> 50,000	< 20
Dry Gas	DG	infinity	None

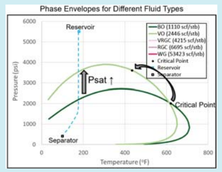
Petroleum fluid can be characterized by many parameters. Gas-oil ratio is one such parameter. The above table is Encana's classification scheme.

Property	Importance
GOR	Indicates fluid type and basis of correlations
Saturation Pressure	Indicates when 2 phase flow begins and relative permeability becomes a factor in performance
Viscosity	Directly related to flow rate shown in Darcy's equation
B_o	Relates production at surface to production at reservoir
CCE/CVD Liquid Dropout	Indication of the volume of liquid that drops out in the reservoir once cross below P_{sat}

Some fluid properties that are determined via fluid PVT analyses.



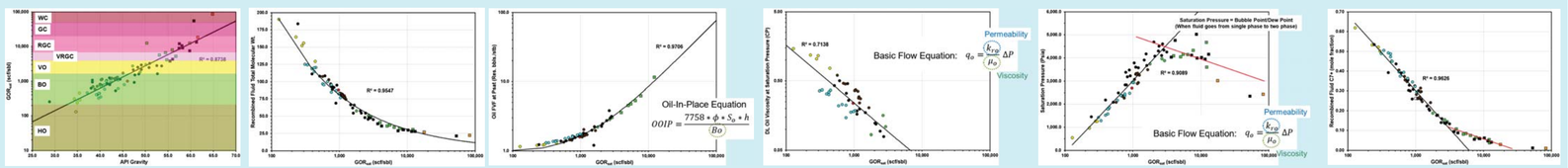
PVT fluid phase envelope and saturation pressure. Saturation pressure is critical because once you cross below relative perm. plays a role.



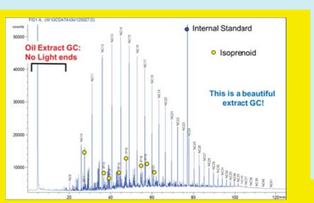
PVT phase envelope and saturation pressure. Phase envelope changes drastically between "black oil" and "volatile oil."

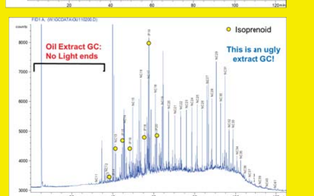
Unconventional shale play PVT database relationships and goals

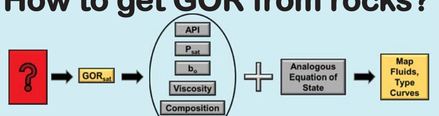
1. Compile data for potential analogs for exploration
2. Predict fluids in basins with limited to no data from core / cuttings

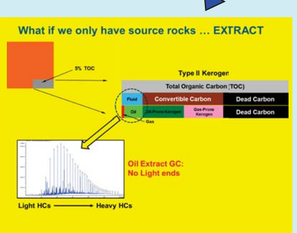


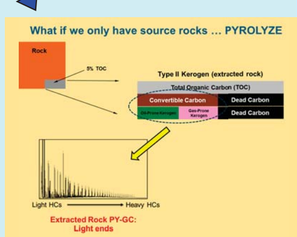
How to get GOR from rocks?

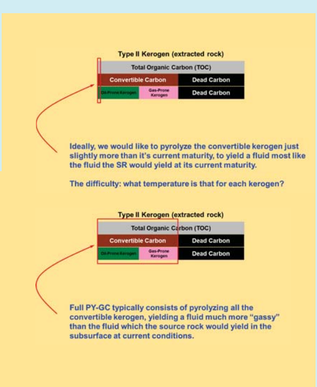




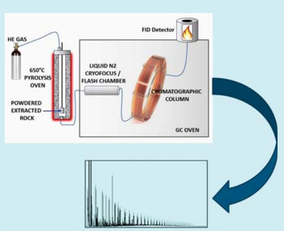




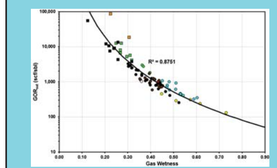




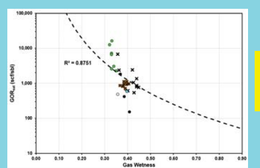
Pyrolysis GC: How it works



Pyrolysis GC Correlations to GOR

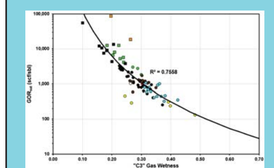


GOR to gas traditional wetness shows a strong relationship within the unconventional shale play PVT database.

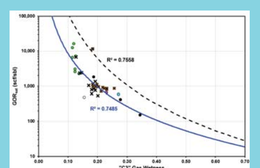


Pyrolysis GC traditional gas wetness from core (solid markers) and cuttings ("x" markers) from PVT database wells or wells offset to the PVT database wells does not show a useful relationship to GOR.

Pyrolysis GC Traditional Wetness shows no correlation to GOR.



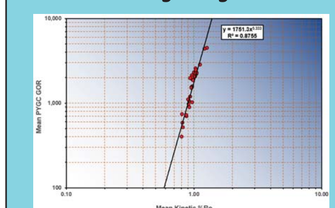
GOR to "C3" gas wetness also shows a strong relationship within the unconventional shale play PVT database.



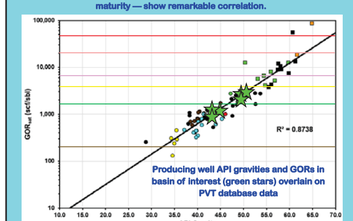
Pyrolysis GC "C3" gas wetness from core (solid markers) and cuttings ("x" markers) from PVT database wells or wells offset to the PVT database wells does show a useful relationship to GOR.

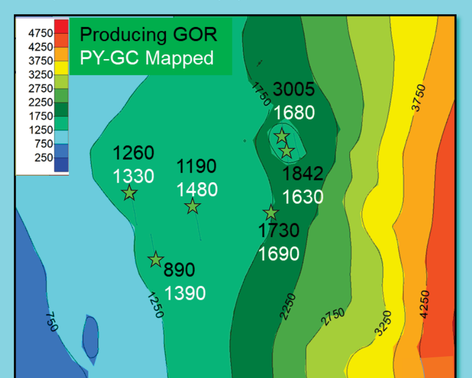
Pyrolysis GC "C3" Wetness based on core and cuttings from the PVT wells or wells offset to the PVT wells shows a good correlation to GOR, especially in the BO to VO GOR range (200 — 4,000 GOR).

Pyrolysis GC GOR Exploration Application



In one basin, two independent methodologies — the pyrolysis GC based workflow for estimating GOR and the one-run kinetic workflow for thermal maturity — show remarkable correlation.





Pyrolysis GC GOR contours over basin mapped based on multiple rock samples taken across basin (locations not shown) and producing well GORs (in black). The GOR values in white are based on the pyrolysis GC GOR to kinetic %Ro cross plot.