Study of the Maximum Retrograde Condensate of Eastern Venezuela Gas Reservoirs and its Impact on Liquid Reserves

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Summary

This study was realized to obtain the volume of maximum retrograde condensate generated during the pressure depletion of gas condensate reservoir, from production parameters easy to obtain in the field during the start of exploitation. For its elaboration, were used 147 PVT of condensate gases from Eastern Venezuela; 88 were consistent in the validation process and only 71 reported MRC volume (Maximum Retrograde Condensate), and these were taking into account for the generation of correlations through linear regressions. The gas condensate characteristics that most influence on the MRC are: percentage of C_7^+, initial gas condensate ratio (GCRi), liquid content (LC) and specific gravity (γgc); using these as independent variables in the new MRC correlations. Best result were obtained with correlation of %MRC vs %C_7^+, that yielded a percentage of absolute average difference of 12,5% when the %C_7^+ of gas condensate is higher of 5,5%. Other correlations obtained with GCRi, LC and ɣgc produced absolute average differences percentage of 21,1%, 15,3% and 25,4% respectively. The new correlations evidently improve the result obtained from the application of Cho Civan y Starling equation (Cho, J., Civan, F. and Starling, K. 2001) to the data of Venezuela Eastern reservoirs. Also, they will improve the characterization of the behavior of gas condensate reservoirs with no PVT information, exploitation plans and condensate reserves calculations.

Introduction

This study was performed in Eastern Venezuela that is one of the most important areas of gas exploitation of PDVSA (Petróleos de Venezuela, S.A); most of its reservoirs are gas condensate, with primary reserves of condensate estimated in $10x10^9$ stb, converting this region in focus of great attention due to its energetic and commercial importance.

The MRC has a direct relation with the maximum saturation of condensate that is formed in the porous media and most of it not reaches mobility, besides the hydrocarbon mixture that is being extracted get poor in such fraction.

The knowledge of the MRC is limited, since the only way to obtain it is through depletion studies in PVT tests, which are not economically justified in small reservoirs. In this case the only way to estimate MRC is by correlations.

Description of fluids samples

After an analysis process of PVT validation, 88 PVTs were consistent and from them 71 that presented the variation of the retrograde condensate volume with pressure, were used in the statistical process.

Characteristics ranges of the gas condensate PVTs used:

- GCRi = 2771 – 253130 scf/stb
- C_7^+ = 0,31% - 15,15%
- MRC = 0,05% - 48,3%
- Pd = 1800 – 5688 psia.

Correlations of γ_{C7+} and γ_{C6+}

Nine PVT tests do not reported specific gravities of the heavy component (γ_{C7}^+ and γ_{C6}^+), for this reason were generated correlations that allow their calculation in function of their molecular weight (M_{C7+} and M_{C6+}).

The correlation of γ_{C7}^+ was developed from 314 data belonging to 117 PVT test from the study, obtaining a coefficient of determination R^2 equal to 0,6756 and a correlation coefficient between variables R equal to 0,8219. See data tendencies in figure 1.

$$\gamma_{C7+} = 0{,}0009 * M_{C7+} + 0{,}6646 \quad (1)$$

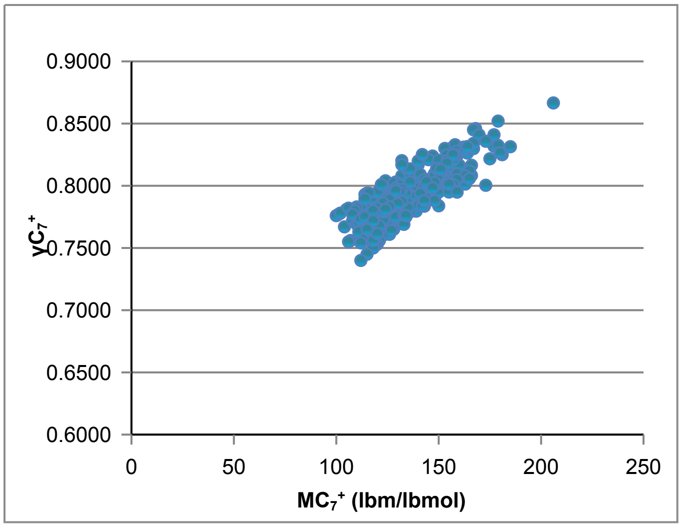


Fig 1—Data trend for γ_{C7+} correlation

When comparing the experimental values of the specific gravity of C_7^+ to the dew pressure (Pd) with respect to the value calculated through the correlations obtained, it was obtained a percentage of maximum difference of 1,54%. The application range of the correlation can be observed in table 1.

Equation	MC_7^+	$\%C_7^+$	API	GCRi
γ_{C7+}	100-206	0,35-13,45	32,2-60,8	2771-253130
γ_{C6+}	134-177	0,78-8,75	45,0-63,0	5430-16474

Table 1—Range of variables used in obtaining the γ_{C7+} and γ_{C6+} correlations

In the same way a general correlation was obtained for specific gravity of C_6^+ with R^2 equal to 0,9309.

$$\gamma_{C6+} = 0{,}0016 * M_{C6+} + 0{,}5572 \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

See data tendencies in figure 2.

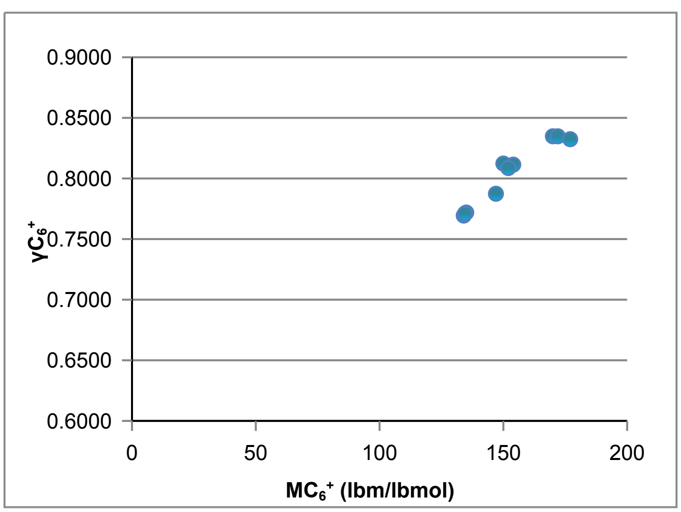


Fig 2— Data trend for γ_{C6+} correlation

Influence of GCRi, LC and C_7^+ on MRC

From each PVT was extracted properties such as: the initial gas condensate ratio in normal conditions (GCRi), the initial separator gas condensate ratio (GCRisep), percentage of heavy component (C_7^+), specific gravity of gas from separator (γ_{gassep}), API gravity of tank condensate, reservoir temperature (from PVT test) and composition of gas condensate (Zi) (in used to calculate molecular weight and the liquid content (LC) of gas condensate).

These properties were represented in a dispersion graphic in MS Excel maintaining as a dependent variable the maximum retrograde condensate in each case, which allowed establish data tendencies and R^2.

For the calculation of liquid content of gas condensate (LC), the equation of Walsh and Lake was used (Walsh, M. and Lake, L. 2003), which has as independent variable the molecular weight of gas condensate (Mgc), for this reason it was necessary to extract from each PVT test the composition of gas condensate at dew pressure.

The influence of the initial gas condensate ratio (GCRi) over %MRC is illustrated in figure 3, generating a coefficient value of variables correlation (R) equal to 0,9186 with a behavior of inverse potential type, due to that major GCRi is indicative of minor formation of liquid during the retrograde condensation.

Similar tendency was obtained for the GCRi of separator (figure 4) with a value of R equal to 0,9011.

The percentage of heavy component (C_7^+) in the gas condensate represents the component that has highest preponderance on the liquid content and the retrograde condensation volume.

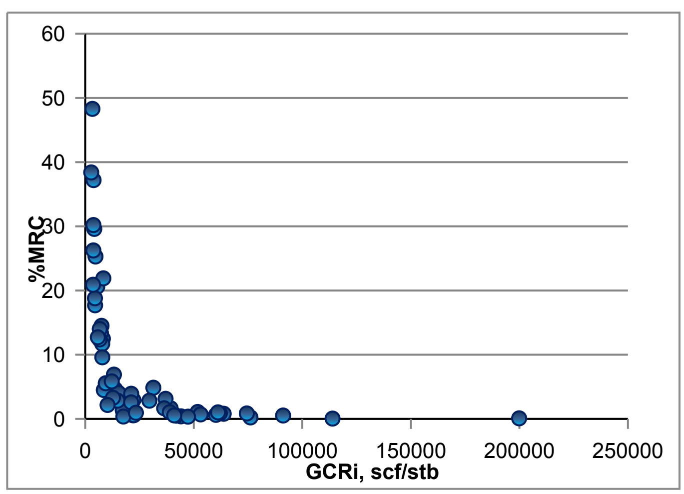


Fig 3—Relationship between the maximum retrograde condensate and the initial gas condensate ratio.

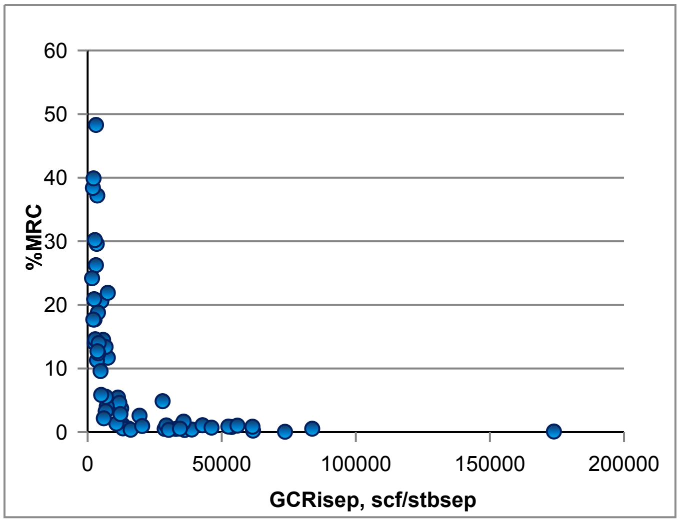


Fig 4—Relationship between the maximum retrograde condensate and the initial gas condensate relation of separator

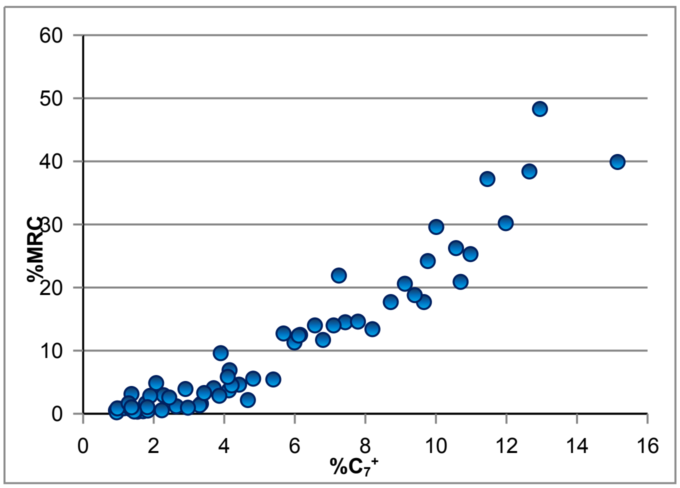


Fig 5—Relationship between the maximum retrograde condensate and the heavy component (C_7^+)

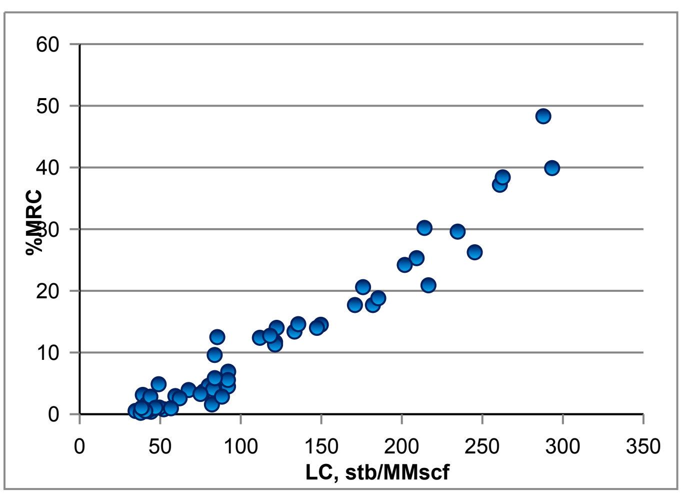


Fig 6—Relationship between the maximum retrograde condensate and the liquid content (LC)

According to the before behavior the figures 5 and 6 show that the maximum percentage of retrograde condensate is directly proportional to the liquid content (LC) and the molar percentage of the heavy component (C_7^+) of the gas condensate. The coefficient of correlation (R) are 0,9647 and 0,9799 respectively.

Other variables of influence on the maximum percentage of retrograde condensate were evaluated: the specific gravity of gas from separator, API gravity and the reservoir temperature, with R^2 of 0,3785, 0,2269 and 0,0728 respectively. None of the three variables above mentioned shown acceptable relations with the maximum retrograde condensate (observe figures 7, 8 and 9).

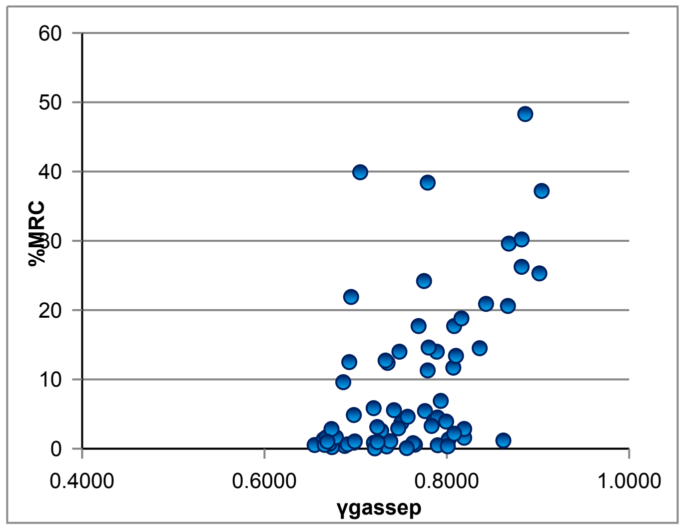


Fig 7— Relationship between the maximum retrograde condensate and the specific gravity of separator gas

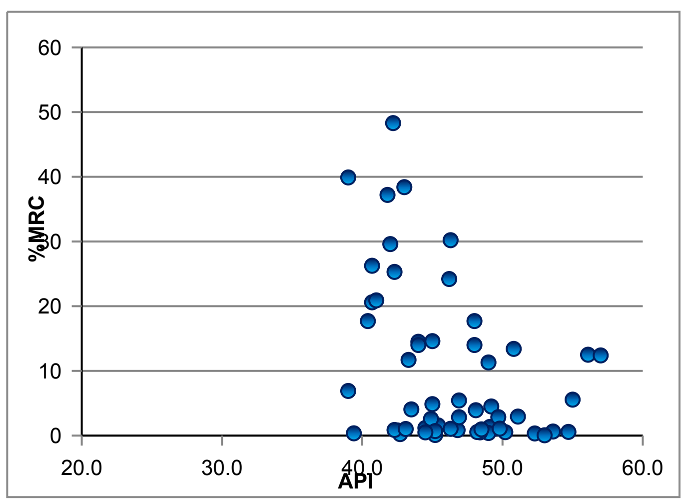


Fig 8—Relationship between the maximum retrograde condensate and the API gravity

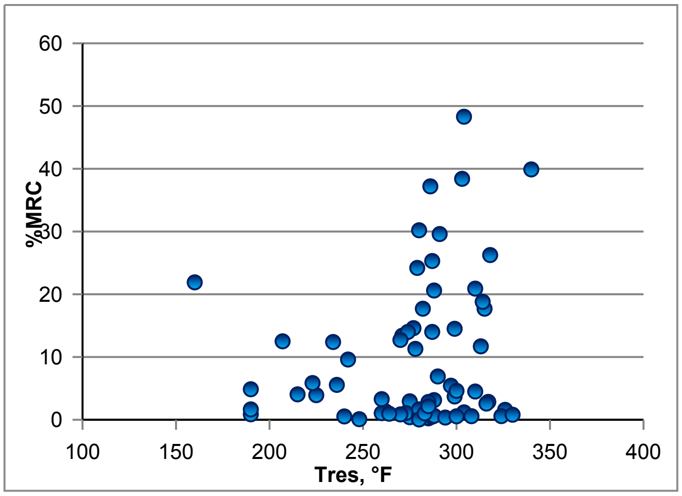


Fig 9—Relationship between the maximum retrograde condensate and the reservoir temperature

Development of MRC correlations

New regrouping of data were made in each one of variables GCRi, $\%C_7^+$ and LC to obtaining the following correlation,

The first correlation was the result of an inverse potential relation between %MRC and GCRi, both variables inversely proportional between them (see figure 10). Such correlation is shown as follows,

$$\%MRC = 4{,}5654x10^6 * (GCRi)^{-1{,}4482} \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

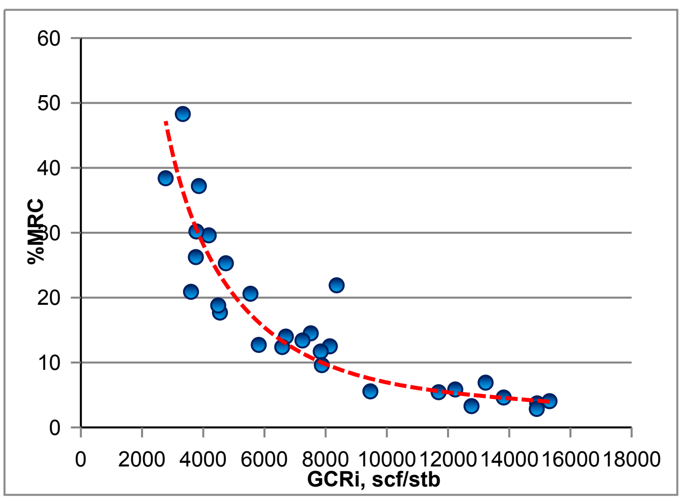


Fig 10—First correlation Maximum retrograde condensate vs initial gas condensate ratio

It was generated from the 29 PVT test data, with R^2 and R of 0,8830 y 0,9397 respectively. Furthermore, it was obtained a percentage of average absolute difference of 21,1% between the experimental and calculated data from the correlation.

The second correlation resulted from a normal potential relation between the %MRC and $\%C_7^+$, both variables are directly proportional between them (see figure 11), and yield the following correlation,

$$\%MRC = 0{,}7616 * (\%C_{7+})^{1{,}4939} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

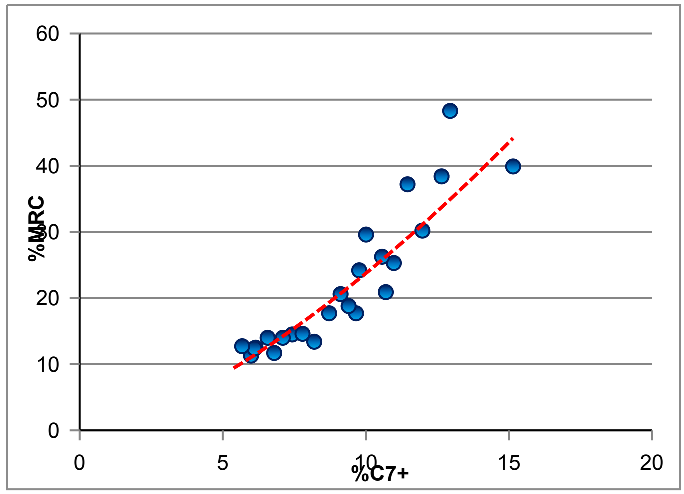


Fig 11—Second correlation Maximum retrograde condensate vs heavy component percentage

It was generated from 24 PVT test data, with values R^2 and R of 0,8724 and 0,9340 respectively. The percentage of average absolute difference is 12,5%.

The third correlation was obtained from a polinomic relation between %MRC and LC. Both variables are directly proportional (see figure 12).

$$\%MRC = 0{,}0004 * (LC)^2 + 0{,}0410 * (LC) + 0{,}5907 \ldots..(5)$$

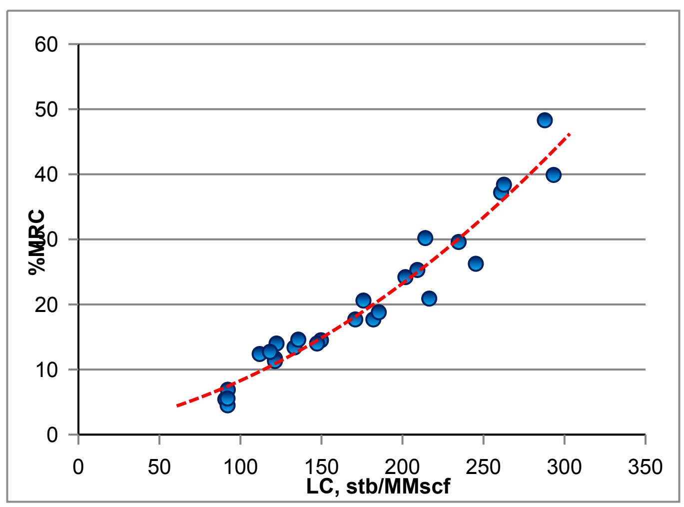


Fig 12—Third correlation Maximum retrograde condensate vs liquid content

Twenty seven (27) PVT tests data were used with values R^2 and R of 0,9419 and 0,9795 respectively. Besides that it was obtained a percentage of average absolute difference of 15,3% between experimental and calculated data.

Table 2 shows the application ranges of the generated correlations.

	Independent Variable	Maximum Value	Minimum Value
First Correlation	Initial gas condensate ratio, GCRi (scf/stb)	15500	2771
Second correlation	Heavy component percentage, $\%C_7^+$	15,15	5,5
Third correlation	Liquid Content, LC (stb/MMscf)	293,29	90

Table 2—Application ranges of the three correlations

Liquid content (eq.6) was obtained (Walsh, M. and Lake, L. 2003) from molecular weight calculate from the PVT tests composition (eq.7). Same calculation was made with the production field data (eq.8) (Rojas, G. 2011). Table 3 shows the percentage difference between Mgc obtained from laboratory data and production field data tests. This procedure allowed to observe that the field data tests can be used when laboratory data (PVT test) is not available.

$$LC = 0{,}023 * (Mgc)^{2{,}444} \quad \text{......................................(6)}$$

$$Mgc = \sum_{1}^{n} Mi * Zi \quad \text{..(7)}$$

$$Mgc = \frac{0{,}07636\ GCRi\ \gamma g + 350\ \gamma c}{0{,}002636\ GCRi + 350\ \gamma c/Mc} \quad \text{.....................(8)}$$

Where γ_c y Mc can be calculated from the following equations (Cragoe, C. 1926):

$$Mc = \frac{44{,}29\ \gamma c}{1{,}03 - \gamma c} = \frac{6084}{°API - 5{,}9} \quad \text{...............................(9)}$$

$$\gamma c = \frac{141{,}5}{131{,}5 + °API} \quad \text{..(10)}$$

Sample	Mgc PVTs	Mgc Field	%Difference
RC2	28,8851	29,3973	1,8
AGV308	33,3404	34,2081	2,6
AGV310	47,4823	48,6961	2,6
JM106	23,0808	23,0462	0,1
RG200	20,8285	20,9142	0,4

Table 3—Percentage difference between the molecular weight of gas condensate obtained from laboratory data and production field data tests

MRC influence on the liquid reserves of Venezuela Eastern gas condensate reservoirs

It was calculated the recovery percentage at abandonment pressure (last level pressure of the CVD test) through a procedure based on data from laboratory (PVT).

This prediction method (Craft, B. and Hawkins, M. 1991) was based in results of gas condensate PVT test of constant volume depletion (CVD) where the liquid phase (retrograde condensate) remains immobile in the bottom of the cell and the gas phase expands during the pressure depletion. This behavior is similar to one that occur during the natural pressure depletion of a volumetric gas condensate reservoir, which produces only the gas phase and the retrograde liquid remains retained in the smallest pores of reservoir. When the reservoir is volumetric, this method simulates approximately well its real behavior.

Four (4) reservoirs were chosen to be studied with the premise that the consistent PVT tests have positives result, especially the molar balance. Immediately were introduced in the programme generated in MS Excel (figure 13 and 14). A sample calculation is shown in appendix. This method can be used to calculate reserves when there is not production data.

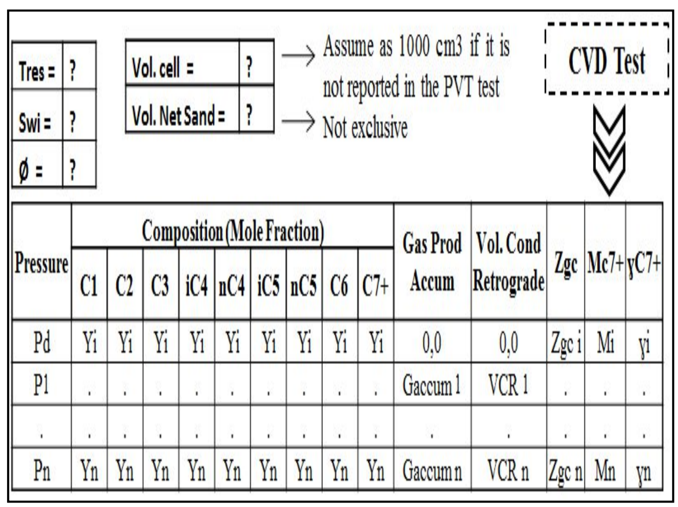
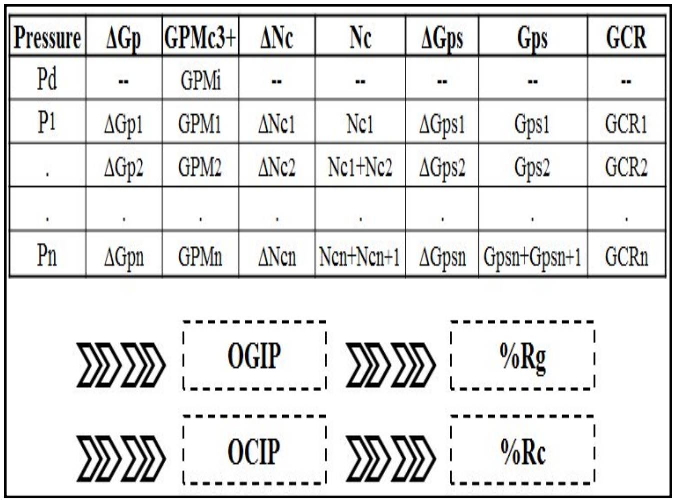


Fig 13—Scheme of input data needed to enter them in the program generated for the calculation of gas and condensate reserves, based on laboratory data, PVT test (CVD)



Pressure	ΔGp	GPMc3+	ΔNc	Nc	ΔGps	Gps	GCR
Pd	--	GPMi	--	--	--	--	--
P1	ΔGp1	GPM1	ΔNc1	Nc1	ΔGps1	Gps1	GCR1
.	ΔGp2	GPM2	ΔNc2	Nc1+Nc2	ΔGps2	Gps2	GCR2
.	.	.	.	.	.	.	.
Pn	ΔGpn	GPMn	ΔNcn	Ncn+Ncn+1	ΔGpsn	Gpsn+Gpsn+1	GCRn

Fig 14—Scheme of output data or results in the program generated for the calculation of gas and condensate reserves, based on laboratory data, PVT test (CVD)

The condensate recovery for reservoirs with medium to low liquid content was less than those reservoirs with a poor liquid content (table 4). The reservoir with higher LC present higher condensation during the pressure depletion and a higher condensate volume remains retained in the reservoir. See table 5 with typical values of gas condensate LC.

Reservoir	LC (stb/MMscf)	%MRC	%Rc @ Pab
MEC RPN54	82,84	4,05	62,1
VEE3 RM1	111,86	12,39	50,4
MET3 RPN55	214,07	30,2	41,1
F5 AGV310	287,85	48,3	31,5

Table 4—Condensate recovery at the abandonment pressure for Venezuela Eastern reservoirs

LC Scale	LC, stb/MMscf
High	300 - 350
Medium	200 -300
Low	100 - 200
Poor	< 100

Table 5—Typical values of liquid content of gas condensate reservoirs

Is necessary to emphasize that is justified the assumption that the condensate is immobile in reservoirs of medium to poor liquid content (< 300 stb/MMscf) and permeability less to 300 mD, due to that in most cases the condensate saturation (Sc) in those reservoir by retrograde condensation only reach 10-15% (Fussell. D. 1972) and critical saturation of condensate (Scc) for sandstone is 20-30% (Ham, J., Brill, J. and Eilerts, C. 1972). Around the production wells where occurs high pressure fall and velocities increases the condensate saturation to values of 30-40% higher than the critical saturation may occur biphasic flow: gas-liquid. But this only occurs in very small portion of the reservoir and the volume of mobile condensate is very low in comparing to the immobile condensate that stay retained in the pores. (Rojas, G. 2011)

Approximation of the moment at which MRC occurs in gas condensate reservoirs of Eastern Venezuela

It is of great importance to know the moment maximum retrograde condensation occurs. The calculation of the relative pressure reduction (Pd-Pmax) with respect to the Pd was calculated with the following equation,

$$f_{Pd} = \frac{Pd - Pmax}{Pd} = 1 - Pmax/Pd \ldots\ldots\ldots\ldots\ldots\ldots\ldots(11)$$

Where Pmax is the pressure at MRC point.

All decrease fractions were grouped and it was applied the frequency distribution method to obtain the relation between the quantity of laboratory studies (PVT) and ranges of f_{Pd}@MRC. Besides that, it was found the relation of this frequency distribution with the liquid content (LC) in the gas condensate reservoirs of Eastern Venezuela. This study was generated with 128 PVT tests that showed the complete pressure depletion study with its respective percentage retrograde condensate, see figure 15.

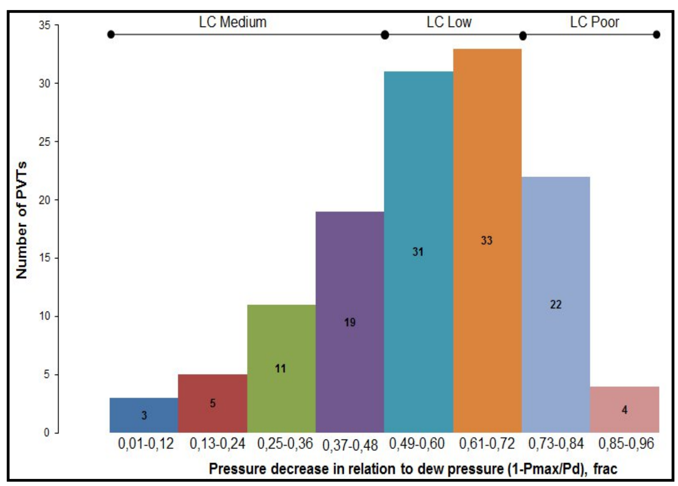


Fig 15—MRC study distribution (PVTs) in relation to the pressure decrease fraction (with respect to dew pressure) and the liquid content.

The 50% of PVT from Eastern Venezuela present low liquid content (LC: 100-200 stb/MMscf) and they reach the %MRC when pressure has decreased between 49% and 72% ($\%f_{Pd}$) with respect to the dew pressure. For example in the case of LCV22 PVT well with a liquid content of 147,29 stb/MMscf, reach its maximum retrograde condensate percentage (14%) when the pressure has decreased 60% (1900 psig) with respect to the dew pressure (4733 psig).

In the last part of left side, PVT data of reservoirs with medium liquid content (LC: 200-300 stb/MMscf), for example RG171 PVT well (LC 293,29 stb/MMscf) reach its percentage maximum retrograde condensate (39,90%) when the pressure has decreased 7% (3225 psig) with respect to the dew pressure (3465 psig), this shows that while higher the liquid content, less time elapses with respect to the dew pressure to reach the pressure to which %MCR ocurrs in the natural depletion of gas condensate reservoirs.

Conclutions

1. The maximum retrograde condensate is inversely proportional to the initial gas condensate ratio and its numerical behavior is inverse potential type with a determination coefficient of 0,8349 (%MRC vs GCRi) and 0,8119 (%MRC vs GCRisep).

2. The molar fraction of heavy seudocomponent (C_7^+) and the liquid content (LC) are the most important indicators of the volume retrograde condensation of a gas, resulting to be directly proportional to the %MRC, with a determination coefficient of 0,9307 (%MRC vs %C_7^+) and 0,9602 (%MRC vs LC).

3. Correlations of %MRC vs GCRi, %C_7^+, and LC, for gas condensates with MRC>4,0% presented the lowest %AAD between the calculated and experimental values.

4. The condensate recovery is less for reservoirs with high liquid content and high maximum retrograde condensation, comparing with those reservoirs with poor liquid content and low MRC.

5. While liquid content is higher, less will be the time that elapses with respect to the dew pressure to reach the pressure to which is obtained the maximum retrograde condensate in the natural depletion of reserves.

Nomenclature

GCRi = initial gas condensate ratio inicial, (scf/stb)
LC = liquid content (stb/MMscf)
Pd = dew pressure, (psia, psig)
API = API gravity of tank liquid
Tres = reservoir temperature, (°F)
PVT = pressure, volume, temperature
CVD = constant volume depletion
M_{C7+} = molecular weight of C_7^+, (lbm/lbmol)
M_{C6+} = molecular weight of C_6^+, (lbm/lbmol)
R^2 = determination coefficient between variables
R = correlation coefficient between variables
Z2f = two face compressibility factor
Zi = molar fraction of component i in the gas condensate
Mgc = molecular weight of gas condensate, (lbm/lbmol)
Mi = molecular weight of component i in the mix, (lbm/lbmol)
Mc = molecular weight of condensate, (lbm/lbmol)
Pab = abandonment pressure, (psia)
Sc = condensate saturation, %
Scc = critical saturation of condensate, %
Pmax = pressure where the MRC is obtained, (psia, psig)
f_{Pd} = fraction of Pmax decrease with respect to dew pressure
%C_7^+ = percentage of heavy component of gas
%f_{Pd} = percentage of Pmax decrease with respect to dew pressure
%MRC = maximum percentage of retrograde condensate
%AAD = average percentage of absolute difference
%Rc = percentage of condensate recovery
γ_{gc} = specific gravity of gas condensate
$\gamma_{gassep} = \gamma_g$ = specific gravity of gas from separator
γ_{C7+} = specific gravity of C_7^+
γ_{C6+} = specific gravity of C_6^+
γ_C = specific gravity of condensate

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Appendix

Sample calculation for prediction of reserves based on laboratory data, reservoir F5, AGV310.

Before applying a prediction method, it is necessary to check if the assumptions made during its development do not significantly deviate from the actual behavior or the characteristics of the reservoir to be studied. The most important for this method:

- The porous volume occupied by the gas condensate remains constant. There is no water intrusion.
- Gas condensate is not associated with an oil zone.

Data:
Pd (psia) = 4160 = Pi
Tres (°R) = 764
Swc (frac) = 0,20
Ø (frac) = 0,18
V.cell (cm^3) = 1000
M_{C7+} = 177
γ_{C7+} = 0,8318
Vol. Net Sand (acre-ft) = 42230

Table 6 shows the laboratory data of the CVD test that was consistent by molar balance in the consistency tests of this reservoir.

CVD tests generally report the volume of retrograde condensate in percentage, and can be converted into volume (cm^3) based on cell volume. Example, for the pressure level of 3515 lpca, a retrograde condensate percentage of 9,243% was reported, then:

$$\%CondRetrog = \frac{Vol.Cond.Retr}{V.Cell} x100 \ldots\ldots\ldots\ldots(1)$$

$$Vol\ Cond\ Retr\ \left(cm^3\right)\ =\ 9{,}243 * V.cell/100\ =\ 92{,}43$$

Then the porous volume occupied by hydrocarbons in the reservoir was calculated:

$$Vph = 43650 * \varnothing * (1 - Swi) * Vol.Net\ Sand \ldots\ldots(2)$$

$$Vph\ =\ 43560\ *\ 0{,}18\ *\ (1 - 0{,}20)\ *\ 42230 = 264893587{,}2\ cuft$$

The conversion factor between Vph and cell volume was calculated by:

$$F = \frac{Vph}{V.cell} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$F = \frac{264893587{,}2}{1000}\ =\ 264893{,}59\ cuft/cm^3$$

With this factor the volume of gas condensate produced (scf) at each pressure level was determined,

$$\Delta Gp = \frac{379{,}4\ \Delta V\ F\ P}{Zgc\ R\ Tf} \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where,
Zgc = compressibility factor of gas condensate at the temperature and pressure level being evaluated and read in the PVT test.
P = pressure at the declination level evaluated in PVT test, psia.
Tres = reservoir temperature, °R.
R = 10,73 psia*cuft/lbmol*°R
ΔV = volume of gas condensate produced in the PVT test cell, cm^3.

$$\Delta Gp\ =\ \frac{379{,}4 * 92{,}43 * 264893{,}59 * 3515}{1000 * 0{,}880 * 10{,}73 * 764} = 4526174{,}6\ Mscf$$

The ΔGp values for the other pressure levels appear in table 7 (col.2).

Then the liquid content of gas produced ($GPMc_{3+}$) was determinated for each pressure level,

$$GPMc_{3+} = \frac{1}{379{,}4} \sum_{i=3}^{n} \frac{Mi\ Zi}{\rho_{li}} \ldots\ldots\ldots\ldots\ldots (5)$$

Where,
Mi = molecular weight of component i, lbm/lbmol
Zi = molar fraction of component i in the gas condensate produced, frac.
ρli = liquid density of component i, lbm/gal. In the case of heavy component, multiply its specific gravity by water density (8,33 lbm/gal).

$$GPM_{C3+} = (2{,}4825 + 0{,}7617 + 1{,}0265 + 0{,}5157 + 0{,}4309 + 0{,}7316 + 8{,}5568)\ =\ 14{,}51\ gal/Mscf$$

Table 7 (col.3) shows the $GPMc_{3+}$ for other pressure.

In a conventional gas-condensate separation system at room temperature approximately 50% of $GPMc_{3+}$ can be recovered as a liquid. Although in a more precise way, separate surface condensate can be obtained making instantaneous vaporization phase calculations in the separators. According to the previous assumption, the condensate produced ΔNc in stb corresponding to an increase in gas condensate production ΔGp, will be given by,

$$\Delta Nc\ =\ 0{,}5\ *\ \Delta Gp\ (Mscf) * GPMc_{3+}(gal/Mscf) * (1stb/42gal) \ldots\ldots\ldots\ldots(6)$$

$$\Delta Nc\ = \frac{0{,}5 * 4526174{,}6 * 8{,}89}{42} = 478969{,}18\ stb$$

Tabla 7 (col.4) shows the ΔNc for other pressure levels.

The condensate produced cumulated Nc, is obtained by adding the ΔNc to a given pressure (col. 5, Table 7)

The separate gas produced (dry or residual) is calculated based on the molar fractions of C_1 (Y_1) and C_2 (Y_2) and 50% of the other components (C_{3+}) in the following way,

$$\Delta Gps = \left(Y_1 + Y_2 + 0{,}5 \sum_{i=3}^{n} Yi \right) \Delta Gp \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$\Delta Gps = (0{,}5956 + 0{,}1097 + 0{,}1183) * 4526174{,}6$$
$$= 3727757{,}38\ Mscf$$

The other values appear in col. 6 of table 7. The col. 7 shows the gas produced accumulated Gps up to a given depletion pressure. The GCR was obtained by dividing ΔGps by ΔNc (col.6/col.4). Calculations of OGIP (Original Gas in Place) and OCIP (Original Condensate in Place) were performed as follows, with the initial gas condensate composition.

$$OGIP = \frac{379{,}4\ Vph\ Pi}{1000\ Zgci\ R\ Tres} \left(Y_1 + Y_2 + 0{,}5 \sum_{i=3}^{n} Yi \right) init \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$OGIP = \frac{379{,}4 * 264893587{,}2 * 4160}{1000 * 0{,}937 * 10{,}73 * 764} * (0{,}5204 + 0{,}1057 + 0{,}1597)$$

$$OGIP = 42770217{,}11\ Mscf$$

$$OCIP = \frac{379{,}4\ Vph\ Pi}{1000\ Zgci\ R\ Tres} x \frac{0{,}5\left(GPMc_{3+}\right) init}{42} \ldots\ldots\ldots (9)$$

$$OCIP = \frac{379{,}4 * 264893587{,}2 * 4160}{1000 * 0{,}937 * 10{,}73 * 764} * \frac{0{,}5 * 14{,}51}{42}$$

$$OCIP = 9399443{,}4\ stb$$

The recovery of gas and condensate at the abandonment pressure of 645 psia, were obtained as follow:

$$\%Rg = \frac{Gps@Pab}{OGIP} x100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

$$\%Rg = \frac{34232207{,}1}{42770217{,}11} = 68{,}0\ \%$$

$$\%Rc = \frac{Nc@Pab}{OCIP} x100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

$$\%Rc = \frac{3529023{,}71}{9399443{,}4} = 31{,}5\ \%$$

Presión (psia)	Composition (Mole Fraction) C1	C2	C3	iC4	nC4	iC5	nC5	C6	C7+	Gas Prod. cm³	Vol. Cond Retrog cm³	Zgc
4160	0,5204	0,1057	0,0902	0,0233	0,0326	0,0141	0,0119	0,0178	0,1295	0,00	0,00	0,937
3515	0,5956	0,1097	0,0878	0,0228	0,0296	0,0120	0,0107	0,0140	0,0597	92,43	456	0,880
2815	0,6164	0,1116	0,0880	0,0210	0,0294	0,0115	0,0090	0,0114	0,0417	221,47	426	0,845
2015	0,6265	0,1143	0,0900	0,0199	0,0294	0,0100	0,0093	0,0097	0,0296	394,85	372	0,853
1215	0,6161	0,1186	0,0959	0,0222	0,0308	0,0115	0,0090	0,0087	0,0237	585,16	329	0,885
645	0,5788	0,1242	0,1048	0,0266	0,0365	0,0142	0,0118	0,0120	0,0279	728,57	282	0,921

Table 6—PVT data (CVD test), reservoir F5, AGV310.

(1) Presión (psia)	(2) ΔGp Mscf	(3) GPM_{c3+} gal/Mscf	(4) ΔNc stb	(5) Nc stb	(6) ΔGps Mscf	(7) Gps Mscf	(8) RGC Mscf/stb

4160	-	14,51	-	-	-	-	-
3515	4526174,6	8,89	478969,18	478969,18	3727757,4	3727757,4	7,8
2815	9045077,4	7,48	805958,99	1284928,17	7543594,5	11271352	9,4
2015	11434939,0	6,64	904350,94	2189279,11	9602490	20873842	10,6
1215	9848800,2	6,57	769947,25	2959226,37	8229657,5	29103499	10,7
645	6255284,4	7,65	569797,35	3529023,71	5128707,7	34232207	9,0

Table 7—Results of calculation method of reserves using laboratory data, reservoir F5, AGV310