WIERTNICTWO NAFTA GAZ • TOM 25 • ZESZYT 2 • 2008

Volodymir Fedyshyn*, Mykhailo Bahniuk*

PECULIARITIES OF HYDROCARBON SYSTEMS OF UKRAINIAN FIELDS

Natural accumulations of hydrocarbon fluids in entrails of the earth are presented by dry gases, in which the content of methane is 99 mole. %, and by natural oils, where the methane part reduces owing to increase of the sum of C_2–C_{5+} components.

In this mineral formation oils and gas-condensates are divided by an area, where exist types of fluids which are different by character of phase transformations. They differ in anomalous values of some physical parameters. For example, initial gas content *G* (ratio of gas and liquid components volumes) of oils in already mentioned area can change from 250 to 1200 m^3/m^3. Retrograde (gas-condensate) systems, which under pressure decrease lower that the beginning of fraction C_{5+} condensation, gradually transform into liquid phase and then partly evaporate, have condensate factor (*CF*) (ratio of liquid and gas components volumes) from 400 to 800 cm^3/m^3.

According to results of experimental investigations methane content in volatile phase of natural oils is on the average 30 mole. %, and the sum of its homologues C_2–C_4 is approximately 15 mole. % [1]. When the content of components C_1–C_5 increases, natural formation oils are replaced in hydrocarbon row by oils of transient state [2]. The quantity of methane in them makes up already 55 mole. %. on the average. Simultaneously the concentration of its light homologues $\Sigma(C_2–C_4)$ rises up to 25 mole. %. The content of heavy hydrocarbon fractions C_{5+} is significantly less. If natural formation oils contain more than 25 mole. % of C_{5+} components, then transient systems contain on the average about 18 mole. % (Fig. 1).

Increasing the number of dissolved volatile components, the oil state approximates to critical phase inversion. Because of shrinkage, which rises up to 75–79 percent, low density and viscosity and also specific character of the components, such fluids are difficult to distinguish from gas-condensates. But, these are, undoubtedly, homogeneous liquid hydrocarbon compounds. Phase transformations occur in them without retrograde features, so after decrease of initial formation pressure p_f in the pools to saturation pressure p_s the process of direct evaporation (degasation) starts. The dissolved gas is educed from liquids.

* L'viv Department of Ukrainian State Geological Research Institute, L'viv, Ukraine

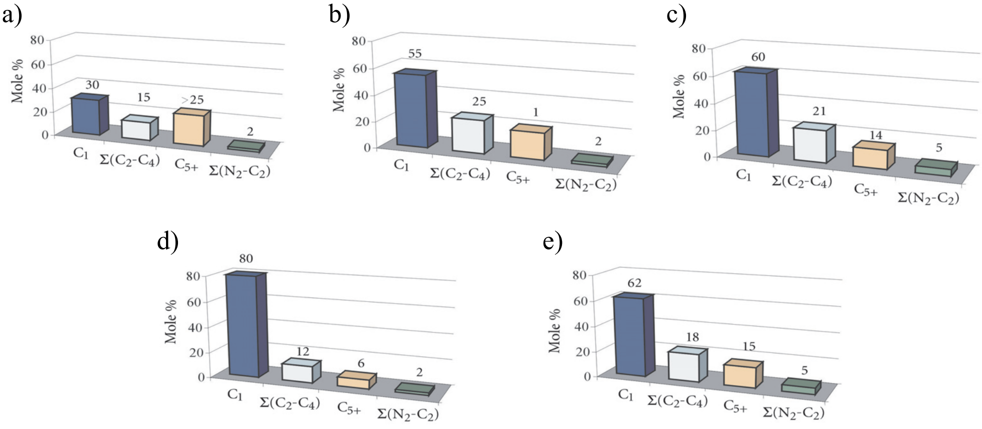

Fig. 1. Components of formation hydrocarbon systems of different phase state: Liguiol state: a) oil; b) oil of transient state; c) closely critical hydrocarbon systems of oil type; gas state: d) gas-condensate systems; e) closely critical hydrocarbon systems of gas-condensate type

We want to mention that in transient from oils to gas-condensate area, hydrocarbon compounds were discovered with practically identical composition, but with significantly different phase state, which, as was mentioned before, approximates to critical state between oil and gas-condensate. Nearly-critical state of oils is indicated by very high initial gas-contents and gas solubility. It is typical for them to have abrupt increase of gas-content ,when pressure is close to initial saturation pressure p_s – this parameter in the interval $0.8 < p_s < 1{,}0$ rises compared to natural oils in 2–5 times, which is caused by progressiveness of gas and liquid hydrocarbons solubility. In oil compounds of nearly-critical state the initial gas content ranges from $G = 750 \div 1200$ m^3/m^3. In their composition there are on the average 60 mole. % of methane, 21 mole. % of C_2–C_4 sum and 14 mole. % of hydrocarbons of C_{5+} fraction (Tab. 1, Fig. 1). The density of oil type nearly-critical systems and gas condensates in formation conditions p_{f} doesn't differ significantly, and under p_s it is identical. Also the significant difference of their viscosity is preserved. Oil pools of nearly-critical state are discovered in Ukraine in Dnipro-Donets depression (DDD) at 2400–5000 m depth, at initial formation pressures 37–55 MPa and temperatures 369–400 K (Tab. 1).

Methane makes up the basis of gas condensate systems. In enough wide-spread formations with average condensate factor(CF) from 100 to 1000 cm^3/m^3 the concentration of this component is 80 mole. % on the average. The sum of its homologues C_2–C_4 is about 12 mole. %. The C_{5+} residue is about 6 mole. % [3]. But in a transient area the volume of liquid hydrocarbons C_{5+} considerably rises up.

Gas-condensate systems of nearly-critical state are discovered in Visean deposits of DDD fields. Their closeness to critical point of phase transformations indicates the character of formation gas differential condensation curves – even under slight (about 10%) decrease of formation pressure towards the pressure of condensation beginning p_{pc}, 90 percent and more of fraction C_{5+} transform into liquid phase. They contain on the average 62 mole. % methane, 18 mole. % $\Sigma(C_2–C_4)$ and 15 mole. % of fraction C_{5+} (see Fig. 1). The value of condensate factor CF for these systems is very high – 1450–3528 cm^3/m^3, which transformed into liquid hydrocarbon phase will show gas-content $G = 690–283$ m^3/m^3 (see Tab. 1).

Table 1

The characteristics of nearly-critical formation hydrocarbon systems

Field	An average depth of pool bedding, m	Thermobaric formation conditions		Content of gases, m^3/m^3	Gas-condensate factor, cm^3/m^3	Components, mole. %						
		pressure p_f, MPa	temperature T_f, K			C_1	C_2	C_3	C_4	C_{5+}	N_2	CO_2
Kharkivtsi	4550	50,7	390	796	–	48,89	13,03	11,31	6,44	17,49	0,92	1,92
Talalayivka	3400	36,7	369	876	–	51,99	13,03	7,58	3,89	12,74	8,95	1,82
Narizhzhia	3930	40,3	377	902	–	74,89	4,37	4,00	2,58	12,18	1,87	0,71
Skorobohat'ky	4690	54,6	398	854	–	68,07	9,14	3,71	1,48	12,93	1,53	3,14
Sary	5019	54,3	400	596	–	62,44	10,09	6,78	2,03	14,60	1,35	2,71
South-Panasivka	3022	31,75	363	–	3528	61,63	6,11	4,14	1,07	22,70	3,96	0,39
Korzhiv	4305	46,50	391	–	1684	72,75	7,21	1,27	0,31	14,86	0,37	3,23
Yarmolyntsi	4295	43,91	391	–	2719	52,97	13,08	7,81	3,09	18,44	1,42	3,19
Talalayivka	3757	39,58	384	–	1613	52,36	6,16	9,95	1,94	15,95	13,10	0,54
Artiukhivka	4066	44,1	388	–	2337	57,96	10,68	7,74	3,00	14,77	3,97	1,88
Artiukhivka	4122	44,9	386,6	–	1681	65,75	9,63	5,60	2,09	13,71	1,29	1,93
Artiukhivka	4104	44,6	386,5	–	1450	62,56	12,94	8,17	3,27	11,31	0,16	1,59
Kharkivtsi	4801	53,1	395	–	2189	62,93	10,08	6,45	2,30	14,87	0,43	2,94
Kharkivtsi	4622	61,2	389	–	2257	71,72	7,86	5,34	2,32	11,11	0,49	1,16

Comparing with oil systems, nearly-critical gas-condensate systems have on the average 2 mole. % more methane and 1 mole. % heavy components C_{5+} and 3 mole. % less of fraction sum C_2–C_4 Non-hydrocarbon components (nitrogen + carbon dioxide) in their composition are practically in the same quantity – about 5 mole. %. So, at condensate factor *CF* more than 1000 cm^3/m^3, methane part and its homologues in gas condensates can be compared with quantity of these components in oils of nearly – critical state (see Fig. 1).

The idea that formation fluids with analogue composition belong to usual or retrograde systems, the authors [4] explain by hydrocarbon peculiarities of fraction C_{5+} and presence in them of certain components. The fundamental importance has the ratio of methane, naphthenic and aromatic rows compounds. It is typical for oils to have relevantly stable admission of methane compounds (to C_{39}) with maximum content of C_{16}–C_{18} components. For gas-condensates the component composition mostly ends up with C_{18}–C_{23} compounds with maximum quantity of hydrocarbons C_7–C_9. The already mentioned differences and also C_2–C_4 compounds content and fraction C_{5+}, depending on thermobaric conditions, determine the specificity of phase transformations.

Oil and retrograde system division in an area where they coexist is impossible using condensate factor or gas content. The condensate factor of such systems ranges from 1450 to 3500 cm^3/m^3, so G = 286–690 m^3/m^3. Most oils of transient state have gas-content from 250 to 700 m^3/m^3. But, despite of different nature of phase transformations, the systems have similar values of density ρ_f, 450–680 kg/m^3 (oil) and 350–480 kg/m^3 (gas-condensates) and volumetric shrinkage. The volumetric shrinkage for oils is 45–72%, for gas--condensate systems it is 50–80% [3]. This means, that from 1 m^3 of formation one-phase liquid after degasation (vaporization) from 0.28 to 0.55 m^3 of separated oil can be left. 0.20–0.50 m^3 of liquid stable condensate can be separated in the formation from 1 m^3 of gas hydrocarbon compound. So, the phase transformation peculiarities practically don't effect the hydrocarbon liquid final output.

As in transient area the fluids of two types exist, we should forecast what will each discovered hydrocarbon mixture present itself. Oils and also gas-condensates can have identical ratio of gas and liquid. Then the industrial information, taken directly by gas and condensate factors measurement during investigations of hydrocarbon fluids, doesn't show phase behavior of systems. It's also impossible to substantiate definitely the hydrocarbon system type using only quantitative ratio of methane and its homologues, density change. To define authentically the nature of such fluids we can only experimentally, using equipment *pVT*, which is adjusted for phase transformations observation.

To define confidently the fluid type, gradual recombination of formation system was proposed with increase liquid-gas factor and at every stage and at different temperatures to measure pressure of one-phase state p_s or p_f, which is illustrated on the sample of B-18 horizon formation system of Sary field (Fig. 2). The identification of fluid type under this condition was complicated by inaccurate measurement of liquid-gas factor because of low wells productivity and small pulsating work. According to value 820 cm^3/m^3 (G = 1220 m^3/m^3) the system was gas-condensated and only according to results of experimental pool exploration the real factor 1677cm^3/m^3 (G = 596 m^3/m^3) was established, according to which the formation system was classified as oil of nearly-critical state. In an area near the critical point of phase transition the type of formation hydrocarbon system practically isn't identifiable.

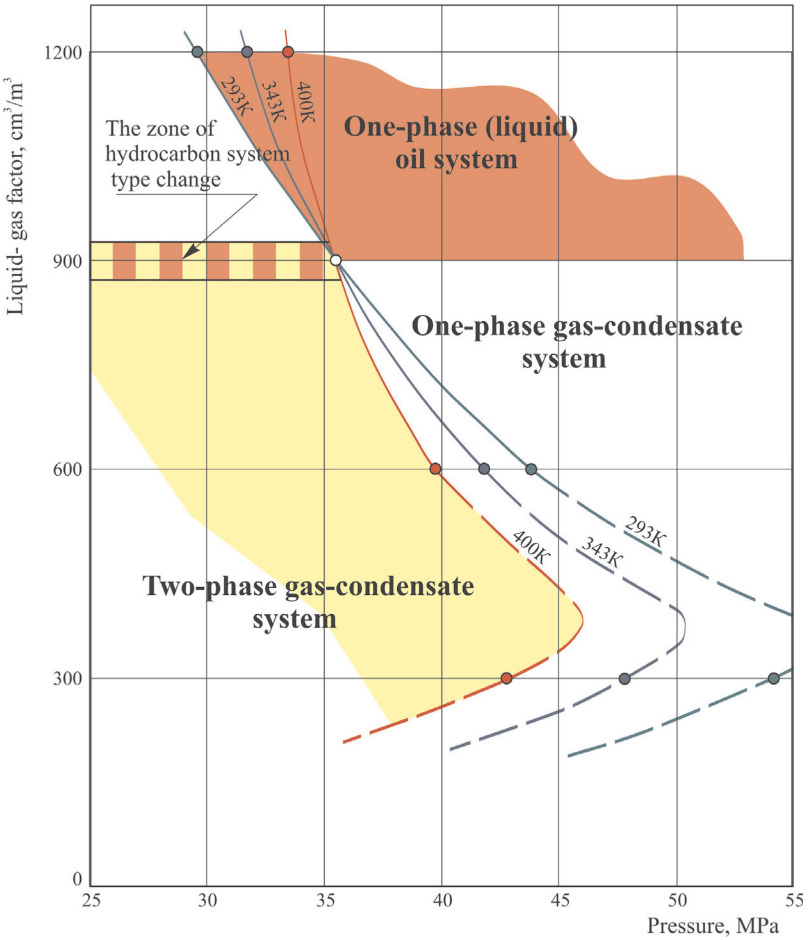

Fig. 2. The results of phase state investigations of formation hydrocarbon system of V-18 horizon in Sary field

To define the fluid type at the stage of exploratory wells testing is very important for calculating the reserves and constructing the development projects, solving problems of efficient expoitation of hydrocarbon pools.

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