LIBYAN GAS COMPOSITION ANALYSIS AND PREDICTION

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Abstract: Gas process or refrigerate always requires specific gas details i.e. gas composition. Generally, types of gas or differentiating between gases depend on composition. The main aim of this study is to evaluate and predict the Libyan gas composition utilizing the triangle plots. The gas composition data (313 old +60 last) collected for most of Libyan reservoirs. Moreover, getting a relation between gas molecular weight and (C_1 +C_2) and hence to find whole other compositions. The average value of every gas component was estimated including the non-hydrocarbon gases. Nevertheless, the isomers and normal structure of C4 and C5 were also obtained.

It is concluded that the old collected data matched and very close to the new or last collected data. However, the gas composition can be easily obtained if gas molecular weight (measured or estimated) at different separator pressure of oil and associated gas.

Keywords: Gas composition analysis, refrigerate, PVT.

INTRODUCTION

Petroleum is a mixture of naturally occurring hydrocarbons which may exist in the soild, liquid, or gaseous states, depending upon the condition of pressure and temperature to which it is subjected. All petroleum is produced from the earth in either liquid or gaseous from, and commonly, these materials are referred to either crude oil or natural gas or associated gas with oil. Oil and gas are naturally existing hydrocarbon mixtures quite complex in chemical composition that exist at elevated temperature and pressure of the mixture are reduced. The state of hydrocarbon mixture at the surface conditions depends upon the composition of hydrocarbon fluid.

Crude oil is the material most sought after of these naturally occurring hydrocarbons, but natural gas is commonly produced along with the crude oil in the early years of the petroleum industry. Natural gas was considered to be a nuisance and was burned at the well site. In years with the advent of transcontinental transmission lines and petrochemical industries, the demand for natural gas as a fuel and a raw product has increased. The value of natural gas to the point where it is no longer a nuisance but a valuable raw material.

Hydrocarbons in reservoir are frequently classified by "base". The earliest such classification system provided three classifications on the basis of composition of hydrocarbon:

a- Paraffin-base, (alkane CnH_2n+2) or oils containing predominantly paraffin series hydrocarbons.

b- Asphatenic-base or oils containing predominantly polyethylene or olefin (alkene CnH_2n).

c- Mixed-base, or oils containing large quantities of both paraffin and polyethylene series hydrocarbon.

Petroleum consists chemically of approximately 11 to 13 wt. % hydrogen and 84 to 87 wt % carbon. Traces of oxygen, sulfer, nitrogen, and helium may be found as impurities in crude petroleum. Although, all petrolum is constituted primarily of carbon and hydrogen, the molecular constitution of crud oils differs widely. About 18 series of hydrocarbons have been recognized in crud petroleum.

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Natural gas is composed predominantly of lower-molecular weight hydrocarbon paraffin hydrocarbon, also called (alkane), any of the saturated hydrocarbons having the general formula CnH_2n^{+2}, (C) being a carbon atom, (H) a hydrogen atom, and n an integer. The paraffins are major constituents of natural gas and petroleum. Paraffins containing less than 5 carbon atoms per molecule are usually gaseous at room temperature. Those having 5 to 15 carbon atoms are usually liquids, and the straight-chain paraffins having more than 15 carbon atoms per molecule are solids.

Gas gravity and molecular weight are widely used to characterize natural gas. Gas gravity is the ratio of the density of a gas at atmospheric pressure and temperture to density of air at the same conditions. The densities of gases are directly proportional to the molecular weight, the gravity is the ratio of the molecular weight of gas to the molecular weight of air. Gas gravities for gases range from 0.6 to 1.1, depending on the relative concentration of the heavier hydrocarbons present in the gas. The main aim of this study is to determine and predict the Libyan gas composition utilizing Tri-angle coordinate plots.

COMPONENTS OF HYDROCARBON

Since hydrocarbon molecules have specific ratios of hydrogen and carbon atoms, hydrocarbon compounds making up petroleum can be grouped chemically into a few series, although each series may have thousands of members. The most common hydrocarbon compounds are those of paraffin/alkenes series which include methane, ethane, propane, butane, etc. They are straight chain or branched configurations of carbon and hydrogen atoms that follow the general formula CnH_2n+2. The alkenes are saturated, that is, the carbon atoms are connected with single bonds. Fig. 1 shows the models used to visualize the structure of these hydrocarbons, and their shorthand formulae.

As longer chains are built, it becomes possible to arrange the carbon atoms in either linear or branched fashion without changing the relative number of carbon and hydrogen atoms. These different arrangements are called isomers and possess different physical properties (Fig. 2). All straight chain alkenes form CH_4 (methane) to $C_{40}H_{82}$ (tetrocontane) have been identified in crude oil typically they amount to 15% to 20% of the oil (Fig. 3). The possible isomers for these alkenes range from two for butane to 6.2 x 1013 for tetracontane. The alkenes are characterized by their chemical inertness, which probably accounts for the stability over long periods of geological times. The first four members of the series (methane, ethane, propane, butane) exist as gases under standard conditions of pressure and temperature. Those from C_5H_{12} (pentane) to about $C_{17}H_{36}$ are liquids and $C_{18}H_{38}$ and higher are wax-like solids. Paraffin is a mixture of these solid members of the series. Saturated hydrocarbons that form closed rings rather than chains belong to a series known as cycloalkanes (also called cycle paraffin or heptanes). These hydrocarbons follow the general formula CnH_2n. Being saturated; they are relatively stable and possess chemical properties similar to those of the alkenes.

Unsaturated hydrocarbons are compounds that contain a carbon-carbon double bond. These compounds can add hydrogen to their structures under appropriate conditions, and are therefore, said to be unsaturated (with hydrogen). One class of hydrocarbons that contains carbon-carbon double bonds is the arene series (also called aromatic because many of them have fragrant odors (Fig. 4). This group is made up of derivatives of benzene, whose formula is C_6H_2n and whose unique structure allows it to be relatively stable and un-reactive. Arene hydrocarbons are either liquids or solids under standard conditions and are common constituents of crude oil.

Other unsaturated compounds include alkenes or cyclo alkenes (also known as olefins) and the acetylene series (triple carbon-carbon bond). Olefin compounds are very uncommon in crude oils and the acetylene series is virtually absent. This is undoubtedly due to their high degree of reactivity and their tendency to become saturated with hydrogen forming alkanes. Of the eighteen different possible hydrocarbon series, therefore, alkanes, cycloalkanes and arenas are the common constituents of most crude oils.

CLASSIFICATION OF HYDROCARBONS

Common oil field classification of oil and natural gas relys on observed producing characteristics and easily measured specific gravity. The gas-oil ratio (GOR), gas gravity and oil gravity are used to categorize reservoir hydrocarbons.

Gas-oil ratio (GOR) in this case refers to the cubic feet of gas produced per barrel of liquid (or cubic meters per cubic meter), with both volumes measured at standard conditions of temperature and pressure.

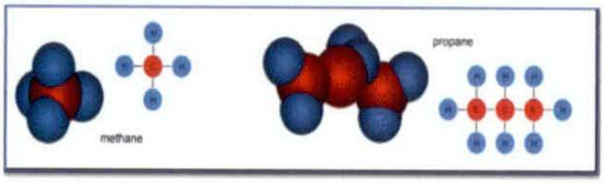

Fig. 1. models for methane and propane, showing the tetrahedral nature of the carbon-hydrogen configuration (Shlumberger, Introduction to welltesting)

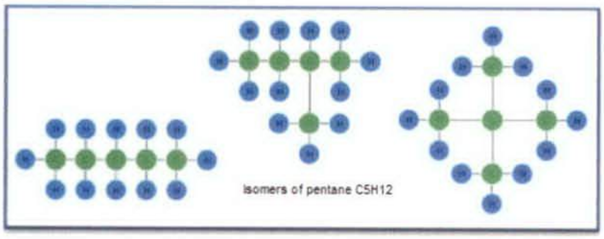

Fig. 2. shows Isomers of pentane (C_5-H_{12}).

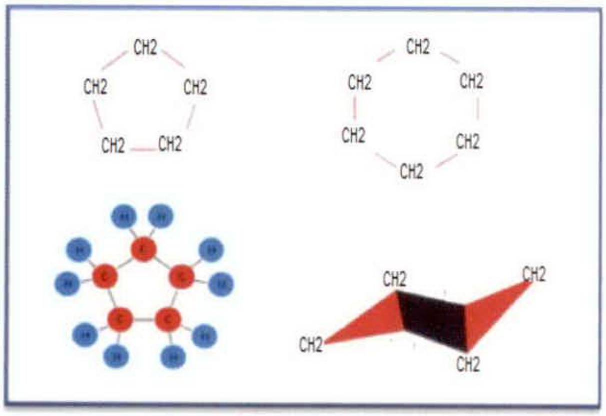

Fig. 3. Structure of two members of the cyclo alkane series of hydrocarbons. Cyclo hexane has an actual three dimensional Geometry that is slightly puckered, not planar as the formula suggests.

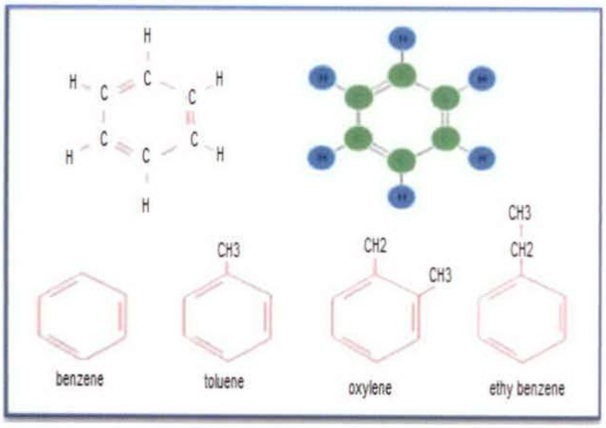

Fig. 4. Structure of several members of the arene, or aromatic, series.

Specific gravity is the ratio of the density of a substance to the density of some reference substance. For gases, the standard reference are dry air at the same temperature and pressure as the gas in question. For liquids, the reference are pure water at 60°F and one atmosphere (14.7 Pisa). For hydrocarbon liquids, the API gravity scale are most commonly used in the oil industry. It expands and inverts the range of numerical values for oil specific gravity. Water has an API gravity of 10.0 and the relationship between API and specific gravity is given as:

$$°API=[141.5/(SP.gr)-131.5] \qquad ...1$$

Table (1) shows the classifications of reservoir fluids based on GOR and fluid gravities. In general, low GOR; low API oils have lesser amounts of the light paraffinic hydrocarbons, while dry gases are composed almost entirely of these compounds. Sampling and analyzing the behavior of dry gas or black oil systems are relatively straight forward procedures. Condensate and volatile oil systems, on the other hand, can be much more complex in terms of their physical chemistry.

PROPERTIES OF NATURAL GASES

Petroleum engineers are usually interested in the behavior of mixtures and rarely deal with pure component gases. Because natural gas is a mixture of hydrocarbon components, the overall physical and chemical properties can be determined from the physical properties of the individual components in the mixture by using appropriate mixing rules.
Knowledge of Pressure-Volume-Temperature (PVT) relationships (Labedi, 1980; Katz & Hachmuth, 1937; Glaso, 1979); Standing, 1970;

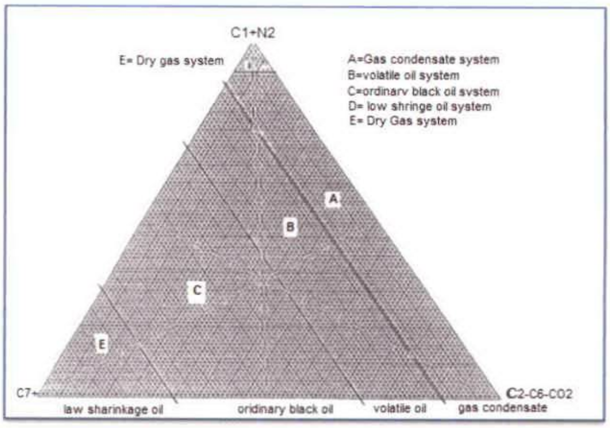

Fig. 5. Compositions of various reservoir fluid types.

Table 1 General categories of reservoir hydrocarbons.

Reservoir fluid	Surface appearance	GOR range	Gas specific gravity	API gravity	C1	C2	C3	C4	C5	C6+
Dry Gas	Colorless gas	Essentially no liquids	0.60-0.65		96	2.7	0.3	0.5	0.1	0.4
Wet gas	Colorless gas with small amount of clear or straw colored liquid	Greater than 100 MSCF/bbl (18000 m3/ m3)	0.65-0.85	60						
Condensate	Colorless gas with significant amounts of light-colored liquid	3 to 100 MSCF/bbl (550-18000 m3/ m3)	0.65-0.85	50-70	87	4.4	2.3	1.7	0.8	3.8
"Volatile" or high shrinkage oil	Brown liquid with various yellow, red or green hues	About 3000 SCF/bbl (550 m3/m 3)	0.65-0.85	40-50	64	7.5	4.7	4.1	3.0	16.7
"Black" or low shrinkage oil	Dark brown to black viscous liquid	100-2500 SCF/bbl (20-450 m3/m3	0.65-0.85	30-40	49	2.8	1.9	1.6	1.2	43.5
Heavy oil	Black, very viscou liquid	Essentially no gas in solution		10.25	20	3.0	2.0	2.0	2.0	71
Tar	Black substance	Viscosity>10000 cp		<10						

Hoffman *et al*, 1953 and Alani & Kennedy, 1960). Other physical and chemical properties of gases is essential for solving problems in natural gas reservoir engineering. These properties include:

- Apparent molecular weight, M_a
- Specific gravity, γ_g
- Compressibility factor, z
- Density, ρ_g
- Specific volume, v
- Isothermal gas compressibility coefficient, C_g
- Gas formation volume factor, β_g
- Gas expansion factor, E_g
- Viscosity, μ_g

The above gas properties may be obtained from direct laboratory measurements or by prediction from generalized mathematical expressions.

This section reviews laws that describe the volumetric behavior of gases in terms of pressure and temperature and also documents the mathematical correlations that are widely used in determining the physical properties of natural gases.

CLASSIFICATION OF RESERVOIR AND RESERVOIR FLUIDS

Petroleum reservoirs are broadly classified as oil or gas reservoirs (Fig. 5). These broad classifications are further subdivided depending on:

- The composition of the reservoir hydrocarbon mixture
- Initial reservoir pressure and temperature
- Pressure and temperature of the surface production

The state of hydrocarbon mixture at the surface condition depended upon the composition of hydrocarbon fluid as produced from the well and upon the pressure and temperature. The fluid renaming in the reservoir at any stage of reservoir at any stage of depletion undergoes physical change as the pressure is reduced by producing quantities of oil or gas from that reservoir. Physical properties of engineer ordinarily are defined in terms of the pressure and temperature at which hydrocarbon exists. Fluids in general are classified as gases, vapor, or liquids, it should be pointed out that particular words convey ideas only when conditions of pressure and temperature are specified.

The conditions under which these phases exist are a matter of considerable Practical importance. The experimental or the mathematical determinations of these conditions are conveniently expressed in different types of diagrams commonly called phase diagrams. One such diagram is called the pressure-temperature diagram or phase behavior or phase envelope.

Gas Reservoirs

A gas is defined as a homogeneous fluid of low viscosity and density that has no definite volume but expands to completely fill the vessel in which it is placed. Generally, the natural gas is a mixture of hydrocarbon and non hydrocarbon gases. The hydrocarbon gases that are normally found in a natural gas are methane's, ethane's, propane's, butanes, pentanes, and small amounts of hexanes and heavier. The non hydrocarbon gases (i.e., impurities) include carbon dioxide, hydrogen sulfide, and nitrogen.

However, if the reservoir temperature is above the critical temperature of the hydrocarbon system, the reservoir is classified as a natural gas reservoir (Ahmed, 2001 & 2007 and Ahmed & McKinny, 2005). On the basis of their phase diagrams and the prevailing reservoir conditions, natural gases can be classified into four categories:

- Retrograde gas-condensate.
- Near-critical gas-condensate.
- Wet gas.
- Dry gas.

Estimating and Measuring Associate Gas Molecular Weight

Molecular weight can be calculated from gas gravity which is predicted from some correlation is available in literature in terms of production data. Vasquez correlate gas gravity maybe estimated from:

$$\gamma_g = gp\,[1+5.912*[10]^{(-5)}(API)(Ts)Log.(P1/114.7)] \quad 2$$

It may be estimated from Katz's correlations (Katz and Hachmuth 1937) that relate total gas gravity to total gas oil ratio and the oil gravity.

Gas gravity may be also calculated gas gravity using which is developed by Labedi (1980).

$$\gamma_g = 0.07547\ [(API)]^{0.6021}\ [(T_S/R_{P1})]^{(0.06593)}\ ((1.19379))/(10\sqrt{(P_1)}) \quad 3$$

Where:

P_1 = First stage separator pressure (Onat, 1975), psia

Ts = First stage separator temperature °F.

γgp = Gravity (air= 1.0) of the gas produced at P_1 and Ts.

°API = Stock tank oil gravity,

R_{P1} = G.O.R. from production at P_1 and Ts, SCF/STB

Gas gravity γg may also be determined using balance method which is the most commonly used method for the field. This instrument compares the density of the gas being tested with the density of air. The calculation of specific gravity is based on the principle that the densities of two gases at base pressure are an inverse ratio to the pressure that provides equal buoyant forces for the two gases. This method of specific gravity determination is used at locations involving both small and large volume sales and purchases of gas. The recommended equipment for use in obtaining gas gravities by the balance method is as follows:

1. The Acme senior gas gravity balance, for use by measurement specialists and all locations where large volumes of gas are tested detailed description in (Fig. 6).
2. The Acme junior gas gravity balance, for use by measurement specialists working with small volumes of casing-head gas. (See Fig. 7).

Recording gravitometers may be used when a continuous record is desirable or required.The types most frequently used are those working use of weighing methods (Fig. 8).

RESULTS AND DISCUSSION

llustration of how to estimate the molecular weight of the gas as a function of composition in percentage of methane and ethane (C_1+C_2) is shown in Fig. (9) which proves a good trend between the molecular weight and the percentage of (C_1+C_2) with difference separator pressure.

The relation between the compositions in percent of the gases associated it selves were also developed; the composition may be estimated from Figs. 11 to 20.

However, utilizing (Fig. 9), it was found that the molecular weight of Libyan gas ranges from 17 to 50. Moreover, the Libyan separator pressure used in the Libyan field ranged from zero to 600 psi. It is appearing from the figure that the molecular weight of gas decreases with increases of (C_1+C_2). Nevertheless, the molecular weights decrease with increase separator pressure. Generally, the straight line relationship between molecular weight and composition can be presented in Table (2).

On the anther hand, Figure (10) can also be used to find gas composition of (C_1+C_2). Any increase in separator pressure will decrease in molecular weight. This effect is major in low (C_1+C_2) gas composition, it may be considered minor in high (C_1+C_2). Figs. 11 to 20 present triangle coordinate utilized for estimation two unknown gas composition if the other third composition is known for old and last data collated from liberating.

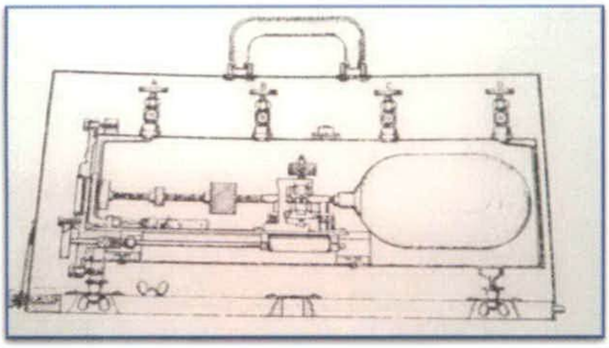

Fig. 6. acme senior gas gravity balance.

Fig. 7. Proptional Torque Differential indicator for measuring the specific gravity gas.

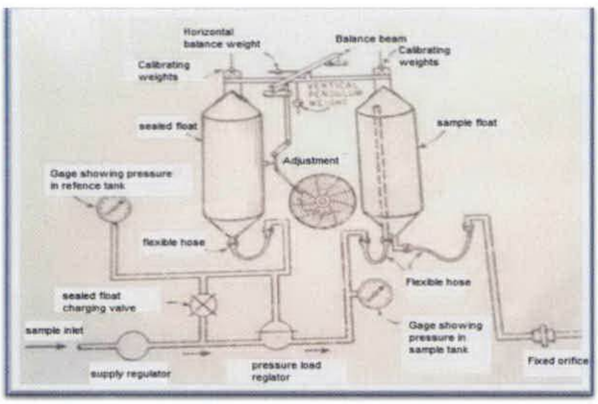

Fig. 8. schematic diagram of a recording gravitometer having gas filled drums suspend from a balance

Table 2 gas molecular weight verses (C_1+C_2) gas composition.

Separator pressure	Equation
Zero	Mwt= 54.54- 0.335* (C_1+C_2)........(4)
50	Mwt=45.61 – 0.263* (C_1+C_2)........(5)
100	Mwt= 41.36-0.227* (C_1+C_2)........(6)
300	Mwt= 34.34-0.168* (C_1+C_2)........(7)
400	Mwt= 32.85-0.156* (C_1+C_2)........(8)
600	Mwt= 26.69-0.095* (C_1+C_2)........(9)

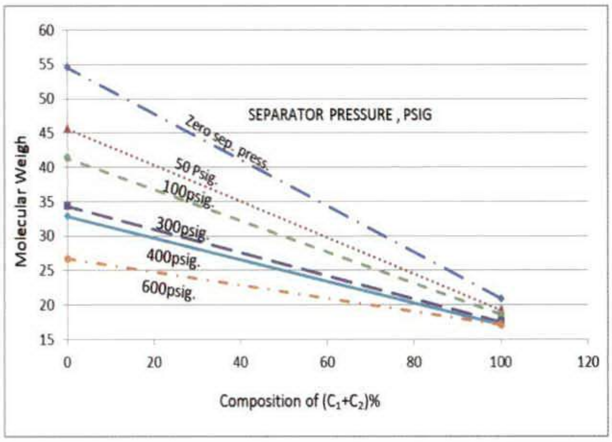

Fig. 9. Molecular weight verses gas composition to different separator pressure.

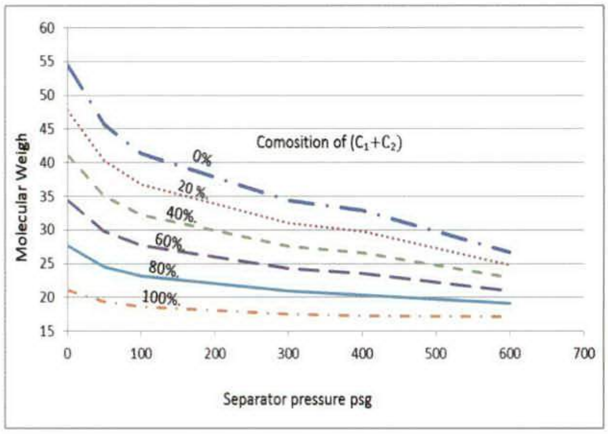

Fig. 10. Molecular weight as function composition

Fig. 11 illustrating relationship between (C_1+C_2) C_3 and $(C_4^+ + N.H.C)$. However, most of (C_1+C_2) a accumulated between 50 to 95 %.

The fitted line equation that maybe used to find C3 is

$$(C_1+C_2) = e^{(0.092*C_3\#)} \quad (10)$$

Where:

$C_3\# = C_3 + (C_1+C_2)/2.0$

Fig. (12) shows (C_1+C_2) as a function of (C_3+C_4) and $(C_5^+ + N.C.H)$. Most of the data contain low values of $(C5^+ + N.H.C)$ that is about 10%.

The equation that can be used for estimation C_4%, from Fig. (12) is:

$$(C_1+C_2) = 209.7 - 2.470\,(C_3+C_4)\# \quad (11)$$

Where:

$(C_3+C_4)\# = (C_3+C_4) + (C_1+C_2)/2.0$

C_1 and C_2 separately can be estimated from Fig. (13) or from equation:

$$C_1 = 0.019 * C2\#^{2.112} \quad (12)$$

Where:

$$C_2\# = C_2 + \frac{C_1}{2.0}$$

The average values of C_2 range from 8 to 18.
C_5 also can be estimated from Fig. (14). Moreover, C_5 can be calculated from the following equation:

$$C_1 = 173.3 - 1.780 * (C_2\text{-}C_5)\,\# \quad (13)$$

Where:

$(C_2 - C_5)\,\square = (C_2\text{-}C_5) + C_1/2.0$

It is appearing that the values of $(C_6^+ + N.H.C)$ low averaged value of about 7%.

Fig. (15) can be used to estimate C_6 with an equivalent value calculated from the following equation:

$$C_1 = 1.88 - 1.942 * (C_2+C_6)\,\# \quad (14)$$

Where:

$(C_2+ C_6)\,\# = (C_2 + C_6) + C1/2.0$

The average value of $(C_7^+ + N.H.C)$ is approximately 6%. C_7^+ and Non Hydrocarbon (N.H.C) dividedly can be estimated from Fig. (16). It can be also calculated by the help of using the following equation:

$$N.H.C = 191.1 - 1.916 *(C_1\text{-}C_6)\,\# \quad (15)$$

Where:

$(C_1\text{-}C_6)\# = (C_1\text{-}C_6) + N.H.C./2.0$

And $C_7^+ = 100 - N.H.C - (C_2\text{-}C_6)$

The average value of C_7^+ is less than 1.0

Most of the Libyan N_2 composition range up 5%. Only, one or few reservoirs may contain higher values. As shown in (Fig. 17) never, it can be calculated from the following equation:

$$N_2 = 0.575\text{-}2E^{-6(CO_2\text{-}H_2S)\#5} + (CO_2\text{-} H_2S)^4\#\text{-}0.006(CO_2\text{-}H_2S)\#^3 + .070(CO_2\, H_2S)\#^2 + 0.207(CO_2\text{-}H_2S)\# \quad (16)$$

Where:

$(CO_2\text{-}H_2S)\# = (CO_2 \text{-}H_2S) + N_2/2.0$

H_2S composition can be obtained after estimating or calculated CO_2 from Figure (18) and calculated from the following equation:

$$CO_2 = 1.167 + 1E^{-05(N^2-H^2S)^{4"}}\, E^{-05(N^2-H^2S)^{4"}} - 0.001(N_2\, H_2 S)^3\# S)^3\# + 0.066(N_2\text{-}H^2S)\#H^2S)\#\ 0.008(N_2\text{-}H_2S)\,\# \quad (17)$$

Where:

$(N_2\text{-}H_2S)\,\# = (N_2\text{-}H_2) + CO_2/2.0$

Average value of CO_2 is about 5%, other values can be higher (30%) in few reservoirs.

To demonstrate other gas composition relationships, Figs. (19) and (20) illustrate this relation.

Fig. (19) shows that even numbers $(C_2+C_4+C_6)$ has low value composite to odd numbers, however, the value of odd numbers ranged between 50% to 100%, whereas the even numbers ranged from 0% to 50%. The equation which can be used to find the exact value are:

$$C_7+(N.H.C) = 0.680 + 0.206\,(C2+C4+C6) \quad (18)$$

Where:

$$(C_2+C_4+C_6)\# = (C_2+C_4+C_6) + \frac{C7+N.H.C}{2}$$

And $(C_1+C_3+C_5) = 100\text{-} (C_2+ C4 + C_6) - (C_7^+ + N.H.C)$

Fig. (20) shows addition way to recognize (C_1+C_3) from $(C_2+C_4+C_5+C_6)$. The equation that can be used is:

$$(C_1+C_3) = 175\text{-}1.751\,(C_2+C_4+C_5+C_6)\,\# \quad (19)$$

Where:

$$(C_2+C_4+C_5+C_6)\# = (C_2+C_4+C_5+C_6) + \frac{(C_1+C_3)}{2}$$

Generally, the value of C_7^+ has low or negligible value in gas phase composition. This true criteria is considered when fitted line was made. Other important point also was considered in case of total gas composition exceed 100% or less than that.

In all previous plots, the isomers or normal values of C_4 and C_5 were not individually estimated.

Figs. (21) and (22) show the relationship between normal C_4 and Iso C_4. Fig. (21) shows a direct simple straight line relationship and Fig. (22) present Log-Log plot.

The equation that can be used to estimate i.C_4 and n.C_4 are from Fig. (21) is:

$$i\text{-}C_4 = 0.103+0.501\,(n\text{-}C_4) \quad (20)$$

Or from Figure (22)

$$i\text{-}C_4 = 0.103 +0.501\,(n\text{-}C4) \quad (21)$$

It is known that

$$C_4 = i\text{-}C_4+n\text{-}C_4 \quad (22)$$

Solving two equations with two unknown, equation (22) can be become

$$n\text{-}C_4 = C_4 - i\text{-}C_4 \quad (23)$$

Subsisting (23) into (20)

$$i\text{-}C_4 = 0.103 +0.501\,(C_4 - i\text{-}C_4)$$
$$\therefore i\text{-}C_4 = 0.103 + 0.501\,C_4 - 0.501\,(i\text{-}C_4)$$
$$1.501\,i\text{-}C_4 = 0.103 + 0.501\,C_4$$
$$\mathbf{i\text{-}C_4 = 0.068621 + 0.333777\,C_4} \quad (24)$$

$$\therefore 0.333777\,C_4 = i\text{-}C_4 - 0.068621$$
$$n\text{-}C_4 = 100 - n\text{-}C_4$$
$$n\text{-}C_4 = 100 - (0.068621 + 0.333777\,C_4)$$
$$n\text{-}C_4 = 100 - 0.068621 - 0.33777\,C_4$$

$$\mathbf{n\text{-}C_4 = 99.931 - 0.33777\,C_4} \quad (25)$$

To find Isomers and normal gas composing of C_5 (Figs. 23 & 24) can be used with normal and Log-Log plot.
The normal plot (Fig. 23) equation is:

$$i\text{-}C_5 = 0.034 + 1.069\,n\text{-}C_5 \quad (26)$$

Also, from Figure (24), the same equation can be obtained.

$$\because C_5 = i\text{-}C_5 + n\text{-}C_5$$

Following the same steps as with C_4 the following equations repress the relation between Iso and normal C_5 with C_5 obtained from the previous triangle coordinate.

$$\mathbf{i\text{-}C_5 = 0.0164 + 0.516\,C_5} \quad (27)$$

$$\mathbf{n\text{-}C_5 = 99\,.98 - 0.516\,C_5} \quad (28)$$

CONCLUSIONS

The conclusions from this study can be presented as following:

1- Utilize Excel Microsoft Office to draw triangle coordinate instead of rectangle plots.
2- The triangle coordinate fitted data points also obtained, there converted to traditional fitted equations of rectangular.
3- The Libyan gas compositions can be easily obtained from this study, if the molecular weight measured directly by the specific instrument.
4- The average of Libyan gas composition may be demonstrated or tabulated in Table 3.
5- The normal and Isomers of C_4 and C_5 range (Table 4).
6- The old (more than 25 years) Libyan gas composition collected data are much closed to the last or recent collected data.

Table 3 the average of Libyan gas composition (El-Ayadi, 1997).

Libyan Gas composition	Range value %	Average value %
C_1	40 - 85	65
C_2	8 - 18	14
C_3	10 - 15	11
C_4	4 -6	5
C_5	1- 5	3
C_6	0 - 2	1
C_7^+	Less than 1	0.5
N_2	0 - 4	3
CO_2	0- 5	4
H_2S	0-0.5	0.4

Table 4 the normal and Isomers of C_4 and C_5 range.

Component	Average value % Maximum	Minimum	Average value %
i-C_4	Up to 8	0 - 3.5	2.3
n-C_4	Up to 18	0 - 5	3.5
i-C_5	Up to 5	0 - 2.5	1.4
n-C_5	Up to 5	0 - 2.5	1.2

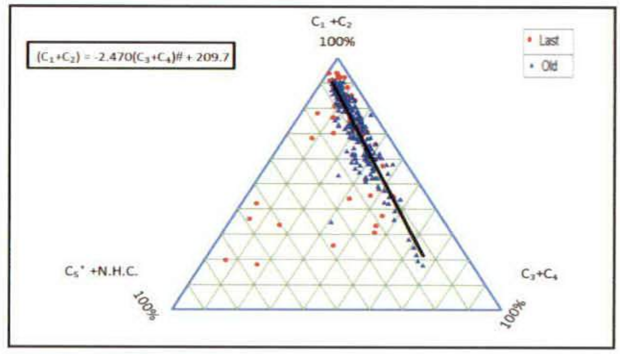

Fig. 11. (C_1+C_2) as function of C_3 and C_4^++N.H.C

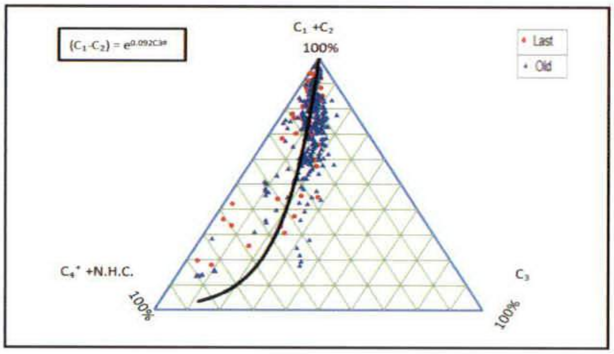

Fig. 12. (C_1+C_2) as faction of (C_3 and C_4) and C_5^++N.H.C

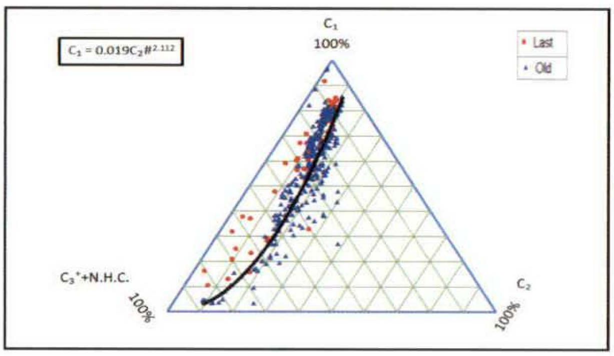

Fig. 13. C_1 as function of C_2 and C_3^++N.H.C

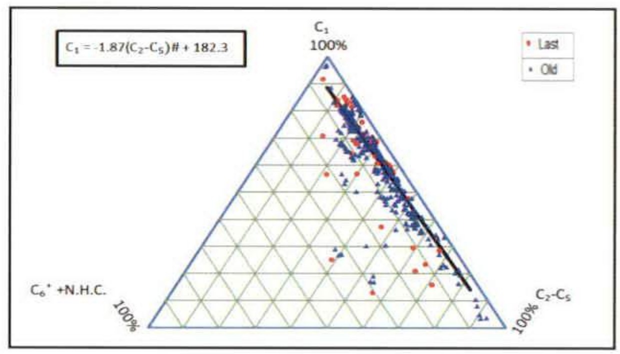

Fig. 14. C_1 as function of (C_2-C_5) and C_6^++N.H.C

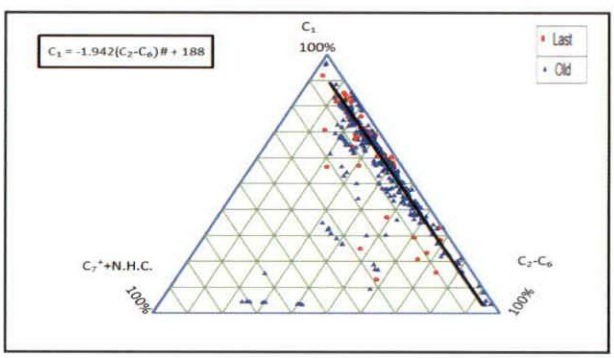

Fig. 15. C_1 as function of (C_2-C_6) and C_7^++N.H.C

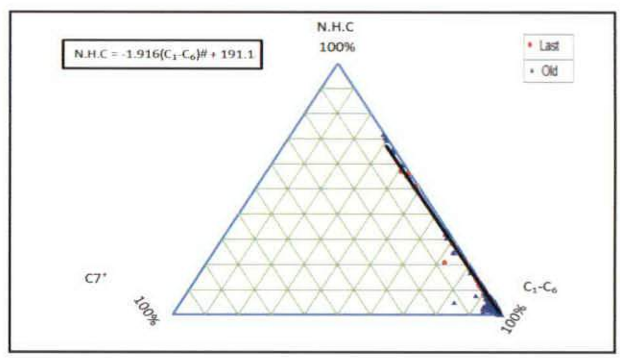

Fig. 16. N.H.C as function of (C_1-C_6) and C_7^++N.H.C

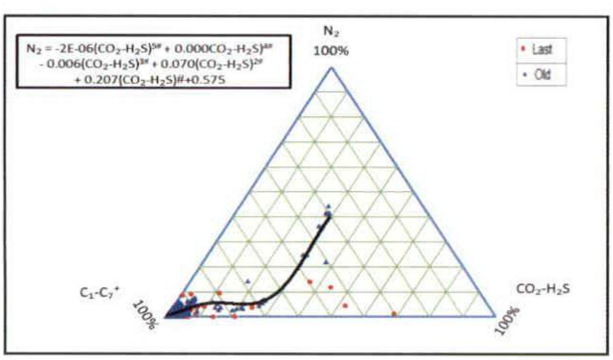

Fig. 17. CO_2 as function of (N_2-H_2S)and C_1-C_7^+

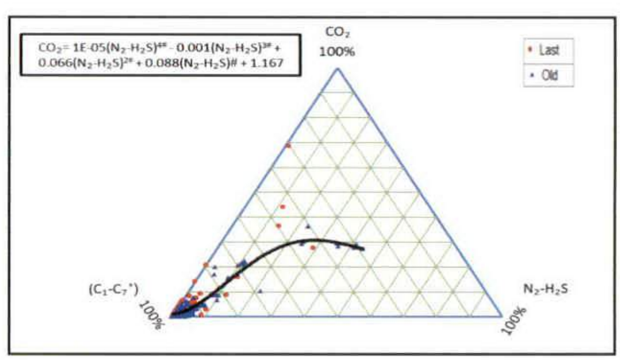

Fig. 18. CO_2 as function of (N_2-H_2S) and (C_1-C_7^+)

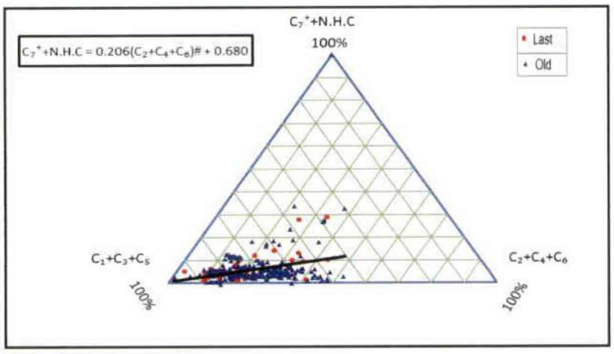

Fig. 19. C_7^++N.H.C as function of (C_2+C_4+C_6) and C_1+C_3+C

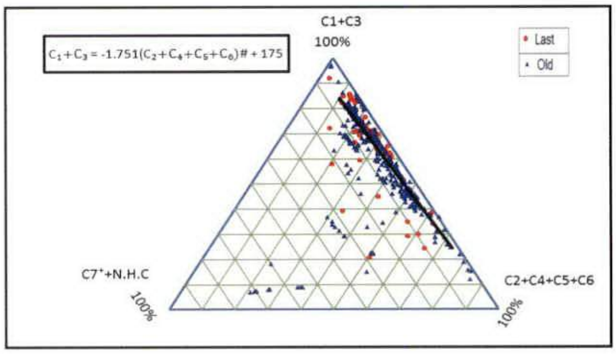

Fig. 20. (C_1+C_3) as function of (C_2+C_4+C_5+C_6) and C_7^++N.H.C

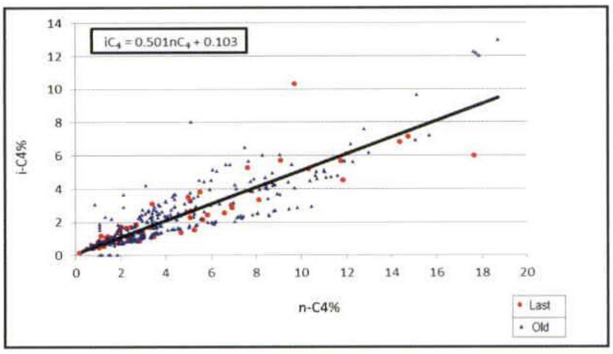

Fig. 21. iC4 as function of nC4 liner plot

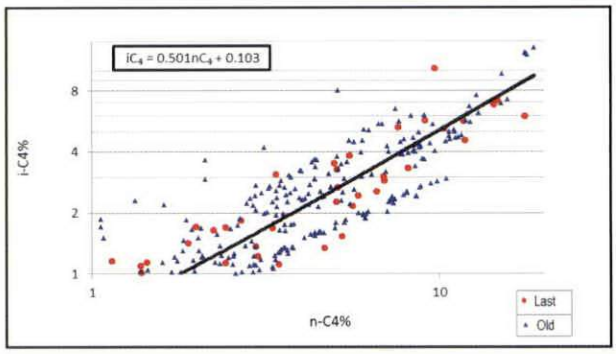

Fig. 22. i-C4 as function of nC4 Log-Log plot

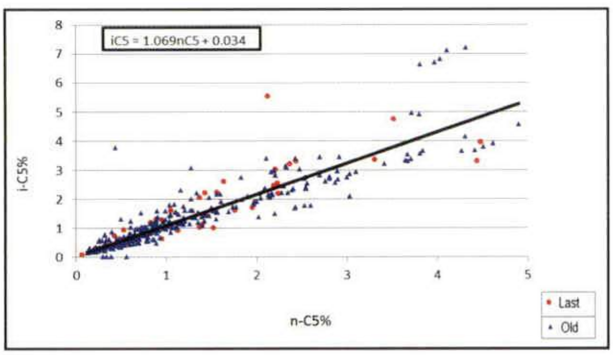

Fig. 23. i-C5 as function of n-C5 liner plot

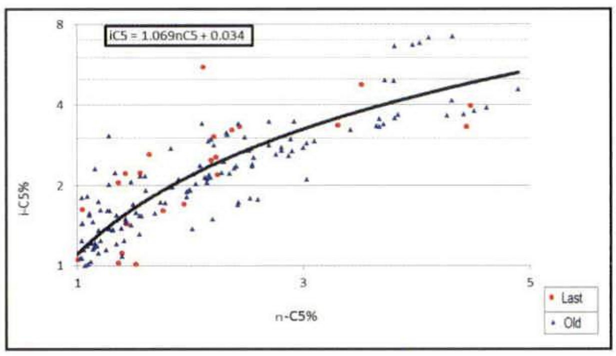

Fig. 24. iC-5 as function of n-C5 Log-Log plot

7- The relationship between associated gas molecular weight and (C_1+ C_2) composition is approximated as straight line at different separator pressure.

8- An average molecular weight of Libyan associated gas range between 17 to 50.

RECOMMENDATIONS

1- Further investigation needed or required to obtained other physical gas properties that can be correlated with composition i.e. pseudo critical properties. Moreover, correlation according to composition instead of weigh density is probably more appropriate.

2- Screen the data and the fields that contain high gas composition i.e. N_2 and CO_2 or H_2S.

3- Utilize the obtained composition for EOR process.

4- Use of the discovered Tri-angle plots or coordinates to find any other properties summated by 100 .i.e. Clay-Sandstone-Dolomite.

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