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Using Light Hydrocarbon Analysis Technique To Evaluate Oil And Gas Layers

Wang Defang[1], Zhao Yin[1], Liu Yachao[2], An Xiaodong[3]

[1] *（College of earth science of Northeast Petroleum University , Daqing ,Hei Longjiang ,China）*

[2] *（The first production plant in Xibei Oilfield , Korla ,Xing Jiang ,China）*

[3] *（The shanshan production plant in Tuha Oilfield , Turpan ,Xing Jiang ,China）*

Abstract: - The identification , evaluation technology is an important link in oil and gas exploration. This paper mainly discusses the use of light hydrocarbon analysis technology to identify evaluation of oil and gas layer. The article makes a detailed description for light hydrocarbon analysis technique principle, evaluation parameters and evaluation methods.Light hydrocarbon analysis technique can reflect reservoir rock hydrocarbon content and the characteristics of the fluid (oil).using the change of the relative percentage of light hydrocarbon parameter to distinguish reservoir properties and watered-out degree is The main difference of the technology and pyrolysis gas chromatography analysis technology. In actual exploration, light hydrocarbon analysis is an economic, rapid and effective method ,and a kind of important means of reservoir evaluation and showing formation characteristics.Therefore, the development and application of light hydrocarbon analysis technique will be more able to adapt to the requirements of identification and evaluation of oil and gas in the future.

Keywords**：** *- Light Hydrocarbon analysis Principle Evaluation Parameters Reservoir Rock*

I. INTRODUCTION

Light hydrocarbon analysis technique began in 1970 in foreign countries, it has been widely used western oil companies, and successfully used for single well evaluation of oil and gas. The technology that using the light hydrocarbon to evaluate oil and gas layer is emerging in recent years, it is not mature. This paper mainly using the method of spectra to identify oil and gas layer, with the deepening of the exploration degree, the technology will become a more and more important method of analysis.

II. HYDROCARBON ANALYSIS TECHNIQUE

2.1 The principle and process of light hydrocarbon analysis technique

Light hydrocarbon is a kind of gas chromatography technology, mainly based on the principle of gas chromatography analysis (Zhang Dianjiang et al, 2001;Li Wu et al, 1997; Wang Zhengping et al, 1997; Chin-chen et al, 2006; Zhang Xiu et al, 2008).Through sealing the oil-bearing sandstone in small bottle, hydrocarbon component of crude oil evaporating into the air of the top of the small bottle, format multi-component mixture gas. Due to the different physical properties and the different relative content of components, there is a certain pressure and saturation vapor pressure under a certain temperature in the mixed gases. Most of the crude oil and heavy components still exist in sandstone as a liquid, so in the light component that evaporated into the air can represent the composition of light hydrocarbons in crude oil. Take a certain amount of mixed gas injection to port into the gas chromatograph, under the carrying of the carrier gas into the chromatographic column, the components start distribute between the mobile phase and the stationary phase repeatedly. Due to the different ability of adsorption and dissolving ,the speed of every component in the chromatographic column is different, after a certain column, separating from each other, ordering leave chromatographic column into the detector, after ion current signal is amplified, a computer automatically record chromatographic peaks and their relative content of each composition.

Light hydrocarbon includes more than 100 monomer hydrocarbon. In the reservoir content and characteristics of the monomer hydrocarbon are controled by of the nature of the hydrocarbon source rocks, alteration of crude oil reservoir, and so on. On the premise of the same organic matter type, thermal evolution degree, mainly identify aquosity of the reservoir by the biodegradation degree of light hydrocarbon compounds and the differences of the solubility in water.

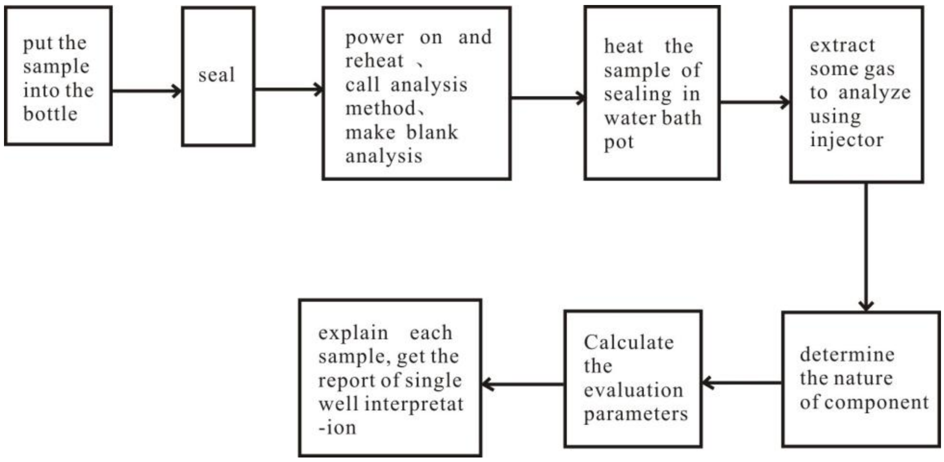

FIG. 1 The process of the light hydrocarbon analysis

2.2 Light hydrocarbon composition and properties

Generally light hydrocarbon refers to hydrocarbon compounds that the carbon number is less than 15 of source rocks, oil or gas, it is an important part of oil and gas, and there is very important and extremely rich geochemical information. Light hydrocarbon analysis is a kind of gas chromatographic analysis technique, chromatography applied to C1 - C5 gas analysis in the early, in the 1990s, and generally applied to the C10 in crude oil. After that it is applied to evaluate source rock and reservoir rock (Du Renzi, 1992; Lang Dongsheng et al, 2007; Rice D 2002;Lang Dongsheng, et al 2004). But in crude oil, the light hydrocarbon from C6 to C9 that is the highest content, most abundant components, biggest change is failed to be analysis and application, the main reason is technical problems , light hydrocarbon sampling, separation is difficulty, the component qualitative and data processing is difficulties also.

After light hydrocarbon generating in source rock, migrating to reservoir to gather, and experiencing further evolution. Therefore, light hydrocarbon compounds in crude oil is the inevitable outcome of the organic matter maturation. In order to comprehensively understand the light hydrocarbon geochemical characteristics, itis necessary to discuss the physical properties of light hydrocarbon in crude oil.

2.3 The light hydrocarbon parameters (Li Yuheng et al 2004)

There are 103 composition before C9 that can be checked out and quality , including 6 monocylic aromatics, 34 naphthenic , 9 n-alkanes , and 54 isomerization alkane , in the table 1 ,there is lists 103 detection of components and their retention time. These parameters cannot be directly applied, the reasons: one is too many parameter, the second is these parameters only reflecting the size of the abundance of each component. So, we must be according to the demand, to induct from a lot of information, and extract the useful information. At present, using the analysis data of light hydrocarbon can solve different problems, solve the same problem using different parameters, such as oil and water layer identification problem, also does not have uniform standard, because various schools defined different parameters, this is the difficulty of application of light hydrocarbon data. If we want to take and optimize an effective evaluation parameters of oil-water layer, we must clear the chemical and physical properties, the main controlling and influence factors of these compounds, otherwise, the oil and water zone evaluation can be difficult to achieve the targeted and effective evaluation.

Table 1 The qualitative table of light hydrocarbon component

The Compound	The relative time retention parameters	The Compound	The relative time retention parameters	The Compound	The relative time retention parameters	The Compound	The relative time retention parameters
CH4	100	T13DMCYC$_5$	186.532	et123TMCYC$_5$	274.663	ETBZ	346.502
C_2H_6	100.448	3EC$_3$	187.699	t14DMCYC$_6$	275.36	234TMC$_6$	347.578
C_3H_8	101.644	t12DMCYC$_5$	188.749	2244DEDMC$_6$	280.637	tt124TMCYC$_6$	349.143
iC_4H_{10}	103.584	224TMC$_3$	189.852	225TMC$_6$	281.601	tt135TMCYC$_6$	351.034
nC_4H_{10}	105.207	NC_7H_{10}	200	tLE3MCYC$_3$	284.646	MXYL	354.858
22DMC$_3$	106.076	MCYC$_6$	217.705	e1E3MCYC$_3$	286.753	PXYL	355.498

iC_5H_{12}	111.251	$C12DMCYC_5$	219.029	$tLE2MCYC_5$	287.999	$23DMC_7$	356.805
nC_5H_{12}	114.517	$22DMC_6$	230.442	$1E1MCYC_5$	289.875	$34DMC_7$	358.574
$22DMC_4$	120.668	$ECYC_5$	228.716	$t12DMCYC_6$	292.509	$34DMC_7$	L/D
CYC_5	127.55	$25DMC_6$	230.785	$cc123TMCYC_5$	298.098	C_9N	360.004
$23DMC_4$	128.112	$24DMC_6$	232.584	$nC8H_{18}$	300	$4EC_7$	361.296
$2MC_5$	128.759	$t124TMCYC_5$	237.62	$iC3CYC_5$	306.791	$23DM3EC_5$	362.575
$3MC_3$	132.969	$33DMC_6$	239.137	C_8N	309.499	$4MC_8$	364.181
nC_6H_{14}	139.236	$tc123TMCYC_5$	244.893	$2M4EC_6$	313.351	$2MC_8$	365.147
$22DMC_3$	148.664	$234TMC_5$	247.719	$235TMC_6$	316.086	C_9N	370.223
$MCYC_3$	150	$233TMC_5$	248.966	$c1E2MCYC_5$	317.501	$3MC_8$	371.326
$24DMC_3$	151.569	TOL	251.111	$22DMC_7$	319.829	OXYL#	375.871
$223TMC_6$	154.146	$23DMC_6$	259.103	$c12DMCYC_6$	324.007	$1M2C_3CYC_5$	382.158
BZ	161.75	$2M3EC_5$	260.247	$44DMC_7$	324.469	$c1E3MCYC_6$	383.261
$33DMC_3$	165.143	$112TMCYC_5$	261.429	$NC3CYC_5$	328.879	$t1E4MCYC_6$	385.574
CYC_6	167.593	$2MC_7$	265.9	$26DMC_7$	330.729	C_9N	388.351
$2MC_6$	174.008	$4MC_7$	267.198	$113TMCYC_6$	334.336	IC_4CYC_5	389.888
$23DMC_3$	174.899	$34DMC_6$	268.367	$35DMC_7$	337.112	$226TMC_7$	391.766
$11DMCYC_3$	176.426	$et124TMCYC_5$	270.307	$233TMC_6$	338.351	C_9N	392.719
$3MC_6$	180.35	$3MC_7$	273.429	$33DMC_7$	339.48	nC_9H_{20}	400
$c13DMCYC_5$	184.433	$E13DMCYC_6$	274.277	$3M3EC_6$	342.229		

III. USING THE LIGHT HYDROCARBON ANALYSIS TECHNIQUE TO IDENTIFY OIL AND WATER LAYER

Light hydrocarbon analysis technique determine the distribution and concentration of light hydrocarbon components from the macro, distinguish reservoir properties by molecular level until the functional groups from the microscopic. According to the relative content, light hydrocarbon concentration of light hydrocarbon, the peak number, scope, components of relative changes of the light hydrocarbon, aromatic hydrocarbons, and more easily dissolved in water of highly branched hydrocarbon heterogeneous functional groups, to discriminate capability of reservoir comprehensively.

3.1 The evaluation parameters of the light hydrocarbon

Analysis of light hydrocarbon component is very more, alkanes, isomerization alkane, cyclanes and aromatic hydrocarbon, there are 103 monomer hydrocarbon altogether. Apply light hydrocarbon to identify oil and water layer, mainly on the basis of reservoir that including water, some component content changing, because of biodegradation and water washing, and so on. evaluation parameters should reflect this change from a large amount of data .The theoretical basis: One is the physical and chemical characteristics of light hydrocarbon component;The other is the main control factors and influencing factors of reservoir oil hydrocarbon characteristics (Wang Xinling ,2008).

On the basis of the above description of the physical and chemical properties of light hydrocarbon and the main control and influence factors of hydrocarbon, separately defines the area of parameters, the ratio of parameters and percentage parameters, there are 30 totally (table 2). Area of parameter respective is the sum of a class of compound /or the total sum of area; Ratio parameters are relatively unstable compounds the sum of area divided by the stable the sum of area; Percentage parameters respective is that the sum of area of a class of compounds is the percentage of the total sum of area .

Table 2 light hydrocarbon evaluation parameters

Serial number	The name	Calculation method
1	A total of area （∑C）	The sum of peak area of 103 components
2	The peak number（cfgs）	The compounds number that detected before C_9
3	The total area of isomerization alkane（∑iC）	IC_4H_{10}、$22DMC_3$、iC5H_{12}、$22DMC_4$、$23DMC_4$、$2MC_5$、$3MC_5$、$22DMC_5$、$24DMC_5$、$223TMC_4$、$33DMC_5$、$2MC_6$、$23DMC_5$、$3MC_6$、$3EC_5$、$224TMC_5$、$22DMC_6$、$25DMC_6$、$24DMC_6$、$33DMC_6$、$234TMC_5$、$233TMC_5$、$23DMC_6$、$2M3EC_5$、$2MC_7$、$4MC_7$、$34DMC_6$、$3MC_7$、$2244DEDMC_6$、$225TMC_6$、C_8N、$2M4EC_6$、$235TMC_6$、$22DMC_7$、$44DMC_7$、$26DMC_7$、$35DMC_7$、$233TMC_6$、$33DMC_7$、$3M3EC_6$、$234TMC_6$、$23DMC_7$、$34DMC_7$、$34DMC_7$(L/D)、C_9N_1、$4EC_7$、$23DM3EC_5$、$4MC_8$、$2MC_8$、C_9N_2、$3MC_8$、C_9N_3、$226TMC_7$、C_9N4 the total of 54 compounds
4	The total area of Quaternary carbon （∑DMC）	$22DMC_3$、$22DMC_4$、$22DMC_5$、$223TMC_4$、$33DMC_5$、$224TMC_5$、$22DMC_6$、$33DMC_6$、$233TMC_5$、$2244DEDMC_6$、$225TMC_6$、$t1E2MCYC_5$、$44DMC_7$、$233TMC_6$、$33DMC_7$、$226TMC_7$the total of 16 compounds
5	The total area of Normal butane and above（∑nC4h）	nC_4H_{10}、nC_5H_{12}、nC_6H_{14}、nC_7H_{16}、nC_8H_{18}、nC_9H_{20}、the total of 6 compounds
6	The total area of Are alkanes（∑nC）	CH_4、nC_2H_6、nC_3H_8、nC_4H_{10}、nC_5H_{12}、nC_6H_{14}、nC_7H_{16}、nC_8H_{18} the total of 8 compounds
7	The total area of Different substituent ring pentane （$∑CYC_5$）	CYC_5、$MCYC_5$、$11DMCYC_5$、$c13DMCYC_5$、$t13MCYC_5$、$t12DMCYC_5$、$c12DMCYC_5$、MCYC、$ECYC_5$、$t124TMCYC_5$、$tc123DMCYC_5$、$112TMCYC_5$、$ct124MCYC_5$、$ct123MCYC_5$、$t1E3MCYC_5$、$c1E3MCYC_5$、$t1E2MCYC_5$、$1E1MCYC_5$、$cc123TMCYC_5$、$iC3CYC_5$、$c1E2MCYC_5$、$nC3CYC_5$、$1M2C3CYC_5$、$iC4CYC_5$ the total of 23 compounds
8	The total area of Different substituent cyclohexane （$∑CYC_6$）	CYC_6、$MCYC_6$、$c13DMCYC_6$、$t14MCYC_6$、$t12DMCYC_6$、$c12DMCYC_6$、$113TMCYC_6$、$tt124TMCYC_6$、$tt135TMCYC_6$、$c1E3MCYC_6$、$t1E4MCYC_6$ the total of 11 compounds
9	The total area of naphthene （∑CYC）	$∑CYC_5+∑CYC_6$
10	The total area of Aromatic hydrocarbon（∑AC）	Bz、TOL、ETBZ、MXYL、PXYL、OXYL the total of 6 compounds
11	The total area of Double methyl pentane（$∑DMC_5$）	$22DMC_5$、$24DMC_5$、$33DMC_5$、$23DMC_5$ the total of 4 compounds
12	The total area of Double methyl hexane（$∑DMC_6$）	$22DMC_6$、$25DMC_6$、$24DMC_6$、$33DMC_6$、$23DMC_6$、$34DMC_6$、the total of 6 compounds
13	The percentage of Quaternary carbon （DMC%）	100*∑DMC/∑C
14	The percentage of Aromatic（AC%）	100*∑AC/∑C
15	The percentage of Isomerization alkane （iC%）	100*∑iC/∑C
16	The percentage of n-alkanes （nC%）	100*∑nC/∑C
17	The percentage of Naphthenic（CYC%）	100*∑CYC/∑C
18	Aromatic/naphthene （AC/CYC）	∑AC/∑CYC
19	Isomerization alkane/naphthene （iC/CYC）	∑iC/∑CYC
20	n-alkanes/naphthene （nC/CYC）	∑nC/∑CYC
21	Aromatic hydrocarbons/n-alkanes	∑AC/∑nC

	(AC/nC)	
22	Isomerization alkane/n-alkanes (iC/nC)	∑iC/∑nC
23	Benzene/cyclohexane (Bz/CYC_6)	the area of Benzene/the area of cyclohexane
24	Toluene/methyl cyclohexane (TOL/ $MCYC_6$)	the area of toluene/the area of methyl cyclohexane
25	Methyl naphthenic index (MCF)	$(2MC_6+23DMC_5+3MC_6)/(c13DMCYC_5+t13DMCYC_5+t12DMCYC_5)$
26	Methyl cyclohexane index/$MCYC_6$ index (%)	$100*MCYC_6/(MCYC_6+\sum DMCYC_5+ECYC_5+nC_7)$
27	Cyclohexane index/CYC_6 index (%)	$100*CYC_6/(CYC_6+MCYC_5+nC_6)$
28	Naphthenic index Ⅰ	$(\sum DMCYC_5+ECYC_5)/nC_7$
29	Naphthenic index Ⅱ	$MCYC_6/nC_7$
30	Heptane values (%)	$nC7*100/\sum(CYC_6\sim\sum MCYC_6)$

3.2 Research on hydrocarbon reservoir evaluation method

The content and distribution of light hydrocarbon compounds of reservoir and crude oil not only depends on the genetic types of crude oil, but also depends on the thermal evolution degree and the intensity of alteration.When the oil source is same, and lithology and physical properties is similar, thermal evolution degree and intensity of secondary evolution that the oil suffered is the same in the adjacent reservoir, the different parameter of a light hydrocarbon is related to oil-water bearing reservoir. When the reservoir is oil-water miscible ,water contain a certain amount of oxygen and all kinds of bacteria, the stronger groundwater dynamic function, the more content of oxygen, the more development of the bacteria depending on oxygen to survive, the bacteria in the water will have bacteria solution and oxidation with the hydrocarbons dissolved in water, leading to a high solubility aromatic hydrocarbon content is reduced, the content of normal alkanes that have high ability to resistance to biodegradation is reduced, but in water, the naphthene that is low solubility and good resistance to biodegradation is relatively stable, according to the change to identify oil and water layer, and establish the judging standards of oil and water layer.

In the process of parameters of light hydrocarbon evaluating reservoir oil, generally ratio parameter has been widely used, to find out the change rule of different reservoir condition with different compound ratio of light hydrocarbon. Choose hydrocarbon component that have the similar or the same carbon number range, or have similar the boiling point to divide, can avoid the influence of temperature and light hydrocarbon lost; Choose the parameters of the different physical and chemical properties to compare, can fully embody the change of parameters. Such as using benzene that have big solubility in the water and n-hexane ratio. Here are several typical spectra characteristics of light hydrocarbon reservoirs:

(1)The oil reservoir

The oil reservoir has the features: high peak of chromatographic flow curve, the peak number is generally more than 60, the peak area is larger, can detect the benzene, toluene, Bz/CYC6 is greater than 0.06, TOL/MCYC6 greater than 0.2, etc;

(2)The atmosphere

Gas has characteristics: because it is composed by the hydrocarbon from C1 to C4, so the range of the peak is narrow, light hydrocarbon gas, the peak abundance value of light hydrocarbon is obviously higher than that of liquid;

(3) The oil-water layers

The oil-water layers have the characteristics: the peak number less, generally between 40 to 60, peak area is medium - large, benzene, toluene can be detected, but the peak is lower, or only toluene can be detected , BZ/CYC6 is between 0.04 and 0.06, TOL/MCYC6 is between 0.1 and 0.2, etc.;

(4)The water layer

The water layer has the characteristics: As a result of the action of water, the components are less seriously, so the peak number is rare, generally less than 40 , peak area is lesser, benzene and toluene can not be detected, BZ/CYC6 is less than 0.04, TOL/MCYC6 is less than 0.1, etc.;

(5) The dry layer

The dry layer: The number and components are less, and the value of the peak is low.

IV. CONCLUSION

Light hydrocarbon analysis technique from the microscopic angle, directly to analyze components and quantity, to obtain more the analysis parameters, to carry on the effective evaluation to the reservoir capability, and to solve the difficult problem of fast drilling to pick sample. The new analysis method can reflect content of hydrocarbon and the characteristics of the fluid (oil) in the reservoir rock, it is playing an important role in the process of oil and gas exploration and development, and it can solve problems in production. Light hydrocarbon technique has developed continually in recent years, oil fields depend on this technology continually. Therefore, taking full advantage of light hydrocarbon analysis technique , will bring new energy to explore, develop and product.

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