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Experimental study and evaluation on hydrocarbon generation of macerals

LIU Dehan[1], ZHANG Huizhi[1], DAI Jinxing[2], SHENG Guoying[1], XIAO Xianming[1], SUN Yongge[1] & SENG Jiagui[1],

1. Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China;
2. Research Institute of Petroleum Exploration and Development, Beijing 100083, China
Correspondence should be addressed to Liu Dehan (e-mail: liudh@gig.ac.cn)

Abstract Some typical coal and maceral samples are selected for oil and gas-generating systematic thermal simulation experiments, Rock-Eval, GC and GC-MS analyses. Results cause productivity curves of extracts and gaseous, light, liquid as well as total hydrocarbon. Effects of macerals and maturation on hydrocarbon productivities and compositions are synthetically discussed. Evaluation indexes and plan on coal-generated oil and gas in bituminous coal rank are suggested according to the data from experiments and analyses.

Keywords: coal maceral, simulation experiment, coal-generated oil and gas, evaluation on coal-generated hydrocarbon.

Amounts of coal basins are over 410 and total coal resources are over $55\,000 \times 10^8$ t in China. The coal resources under 1 000 m are more than 53% of the total coal resources, which is an important sphere of exploring oil and gas derived from coal. Large coal-generated gas field and important coal-generated oil field are separately found in the Ordos Basin and the Tuha Basin at present. Genesis and evaluation on coal-generated oil and gas are theoretical and practical problems in exploring and evaluating coal-generated hydrocarbons. Researchers[1—11] studied and discussed the origin and valuation on generated oil and gas from various angles. On the basis of these research achievements, we select some typical coal and maceral samples for oil and gas-generating systematic thermal simulation and other analysis experiments and go further into study on the origin and valuation of coal-generated oil and gas. In this paper the hydrocarbon potential and evaluation of coal and macerals is only discussed.

1 Selection and basic character of samples

(i) Selection and preparation. The desmocollinite, telocollinite and inertinite samples in this study are mainly from the Tuha Basin, where coal-generated oil and gas is produced, and the Yili Basin, where industrial coal-generated oil and gas is not found at present. The three macerals are more distributed in coal and further enriched under the microscope. Exinite and alginite samples, contents of which are normally low but extremely important macerals on hydrocarbons generation, are from special type coals and further separated by heavy liquid. Localities and character of the studied samples are shown in table 1.

Table 1 Locality and character of the samples

No.	Locality	Time	Depth/m	Sample name	Purity (%)	R_o (%)	H/C	O/C
G1	Yan 3 well in the Tuha Basin	J_1b	2 492	telocollinite	91	0.60	0.88	0.28
G2	Sandaoling in the Tuha Basin	J_2x		cutinite semibright	crude coal	0.58	0.86	0.17
G3	Sandaoling in the Tuha Basin	J_2x		semibright	crude coal	0.58	0.72	0.16
G4	Mi 1 well in the Tuha Basin	J_2q	2 598	desmocollinite	86	0.53	0.98	0.23
G5	Yan 3 well in the Tuha Basin	J_2b	2 492	desmocollinite	78	0.60	0.92	0.26
G6	Fushun, Liaoning	E		cannel	crude coal	0.54	1.19	0.12
G7	Leping, Jiangxi	P		suberinite	88	0.60	1.12	0.07
G8	Lsh 1 well in the Tuha Basin	J	3 935	clarain	crude coal	0.67	0.72	0.09
G9	Luquan, Yunnan	D		cutinite	78	0.55	1.43	0.09
G10	Canada	D		sporinite	77	0.52	1.27	0.19
G11	Maoming, Guangdong	E		humic coal	96	0.32	0.92	0.31
G12	Minhe, Gansu	J		alginite	97	0.49	1.56	0.08
G13	Yili Basin, Xinjiang	J_2x	1 689	inertinite	82	0.38	0.63	0.25
G14	Yili Basin, Xinjiang	J_1b		semibright	crude coal	0.53	0.94	0.17

(ii) Results of Rock-Eval analysis. Data of Rock-Eval analysis are important indexes which are widely applied to the valuation of source rocks. Rock-Eval data of coal and maceral samples are shown in table 2.

Table 2 Rock-Eval data of various coal samples

No.	Locality	Depth /m	Lithology	Time	TOC (%)	T_{max}/ ℃	S_1/ mg • g^{-1}	S_2/ mg • g^{-1}	S_1+S_2/ mg • g^{-1}	TPI	HI	PC	D	HCI
G1	Yan3 well in the Tuha Basin	2 492	telocollinite	J_1b	67.84	434	1.07	26.85	27.92	0.04	39	2.3	3.41	1.6
G2	Sandaoling in the Tuha Basin		semibright	J_2x	74.29	433	1.48	148.51	149.99	0.01	200	12.45	16.76	2.0
G3	Sandaoling in the Tuha Basin		semibright	J_2x	72.43	432	1.78	86.25	88.03	0.02	119	7.31	10.09	2.5
G4	Mi 1 well in the Tuha Basin	2 598	desmocollinite	J_2q	60.65	427	10.71	128.03	138.74	0.08	211	11.52	18.99	17.7
G5	Yan3 well in Tuha Basin	2 492	desmocollinite	J_1b	54.13	427	4.44	90.92	95.36	0.05	168	7.91	14.62	8.2
G6	Fushun, Liaoning		cannel	E	75.25	434	9.28	414.64	423.92	0.02	551	35.19	46.76	12.3
G7	Leping, Jiangxi		suberinite	P2	65.11	439	18.00	390.90	408.9	0.04	600	33.94	52.13	27.6
G8	Lsh 1 well in Tuha Basin	3 925	clarain	J_2x	78.22	438	17.03	135.92	152.95	0.11	174	12.69	16.23	21.8
G9	Luquan, Yunnan		cutinite	D	65.48	443	28.04	512.98	541.02	0.05	783	44.90	68.58	12.8
G10	Canada		sporinite	D	37.20	433	6.42	220.71	227.3	0.03	593	18.87	50.71	17.7
G11	Maoming, Guangdong		humic coal	E	57.96	431	4.64	38.57	43.25	0.11	67	3.59	6.49	8.0
G12	Minhe, Gansu		alginite	J	64.54	443	25.98	552.52	578.5	0.04	856	48.02	74.40	40.3
G13	Yili, Xinjiang		inertinite	J_2x	66.02	433	2.17	3.69	5.86	0.37	6	0.49	0.74	3.3
G14	Yili, Xinjiang		clarain	J_1b	72.81	434	4.69	143.87	148.56	0.03	198	12.33	16.94	6.4
G15	Tuha Basin		coal core	J_1x	49.67	429	6.92	101.9	108.8	0.07	181	8.25	16.33	13.6
G16	Tarim Basin		slack	J	50.32	448	5.67	112.4	118	0.06	220	9.85	19.25	11.45
G17	Yili Basin		slack	J_2x	56.76	427	1.30	35.17	36.47	0.03	66	3.03	5.62	2.03
G18	Yili Basin		slack	J_2b	54.84	428	2.45	123.4	125.8	0.02	231	10.48	19.56	4.76

Rock-Eval data of alginite, cutinite, sporinite, suberinite and cannel coals are very high. The S_1 values are from 6.4 to 28.04 mg/g, averaging 17.54 mg/g. The S_1+S_2 values are from 227 to 578 mg/g, averaging 435.9 mg/g. The HI values are from 551 to 856 mg/g, averaging 676.6 mg/g. These data show that the special types of coal are best hydrocarbon-generating maceral.

The S_1 value of desmocollinite is 10.71 mg/g, showing that hydrocarbon content of the sample is high; the S_1+S_2 value is 138.74 mg/g and the HI value is 211 mg/g, higher than that of vitrain and crude coal.

The S_1 values of telocollinte and humic coal are from 1.07 to 4.64 mg/g; the S_1+S_2 value of which are 27.85—43.25 mg/g and the HI value is 39.67 mg/g, lower than that of desmocollinite coal.

The S_1 value of inertinite coal is 2.17 mg/g; the S_1+S_2 value is 5.86 mg/g and the HI value is 6 mg/g, showing that hydrocarbon potential of inertrinite coal is very low. The S_1 value of sample is slightly high since fusain of the sample is filled by a little of exinite.

Tuha Basin: The S_1 values are from 1.48 to 17.03 mg/g, averaging 6.92 mg/g. The S_1+S_2 values are from 38.7 to 162.4 mg/g, averaging 108.8 mg/g. The HI values are from 98 to 250 mg/g, averaging 180.6 mg/g. These data are higher than those of coal samples from the Yili Basin.

Tarim Basin: The S_1 values are from 1.15 to 9.01 mg/g, averaging 5.67 mg/g, lower than those of coal samples from the Tuha Basin. The S_1+S_2 values are from 48 to 213 mg/g, averaging 118 mg/g, less difference than those of coal samples from the Tuha Basin. The HI values are from 139 to 436 mg/g, averaging 220.5 mg/g, showing that coal samples are better hydrocarbon-generating coal.

Yili Basin: Rock-Eval data in table 2 show that hydrocarbon potential of coal from the Xishanyao Group is far lower than that of coal from the Badaowan Group.

2 Thermal simulation experiments of oil and gas generation of coal

Although results from thermal simulation could not be compared with oil and gas generative practices in geological conditions, yet are an important basis of evaluating hydrocarbon potential and exploring valuation on oil and gas-generating coal. Ten samples (G1, telocollinite; G4 and G5, desmocollinite; G6, cannel; G7, suberinite; G8, clarain with lipids; G9, cutinite; G10, sporinite ; G11, humic coal; G12, alginite ; G13, inertinite) in table 1 were used in thermal simulation.

(i) Experimental. Samples were separately sealed into glass-tube and heated at 200, 240, 280, 320, 360, 400℃ for 100 h. After cooling, sample tubes were opened to analyze contents of gases with HP 5890II GC and SC-4 GC.

The gas-excluded sample tube was at once at 120—130℃ to purge with N_2 for 1 h. The light hydrocarbons purged out were collected in a cooled trap in liquid nitrogen and weighted, and analyzed with GC, GC-MS.

The purged samples residues were extracted with chloroform. The extracts were weighted and separated into group composition. The alphatic components were analyzed with GC and GC-MS.

(ii) Results. The results are listed in table 3. The gas hydrocarbon productivities of various coal samples are shown as mL/g and mg/g. The productivities of light hydrocarbon, chloroform bituminous, liquid hydrocarbon and total hydrocarbon are shown as mg/g against R_o: 200℃, R_o 0.7%; 240℃, R_o 0.8%; 280℃, R_o 0.9%; 320℃, R_o 1.2%; 360℃, R_o 1.5%; 400℃, R_o 1.98% (figs. 1—4).

(1) Gas hydrocarbon productivity (GHP). Results show the increase of the GHP of various coal samples with temperature increasing. But there is a great difference among the GHP of various coal samples. The sequence of the GHP at 400℃ is alginite (G12) 350 mL /g > cutinite (G9) 335 mL /g > suberinite (G7) 246 mL /g > cannel (G6) 224 mL /g > sporinite (G10) 182 mL/g > desmocollinite (G5) 164 mL/g and desmocollinite (G4) 122 mL/g > humic coal (G11) 120 mL/g > telocollinite (G1) 98.6 mL/g > inertinite (G13) 29.5 mL/g. The highest GHP of alginite is 3.5 times higher than that of inertinite.

Fig. 1 illustrates differences among the GHP of some major macerals. In fig. 1, the average productivity of gas hydrocarbon of samples G1 and G11 is regarded as the GHP of vitrain, that of samples G4 and G5 as the GHP of desmocollinite coal, that of samples G9, G7 and G10 as the GHP of exinite coal, that of sample G12 is gas hydrocarbon productivity of alginite coal, and that of sample

Table 3 Hydrocarbon productivities of various coal samples in thermal simulation

Temperature /℃	Product[b)] /mg · g⁻¹	Sample No.									
		G1	G4	G5	G6	G7	G9	G10	G11	G12	G13
200	gas H.	(0.236)	(0.200)	(0.384)	(0.048)	(0.042)	(0.0086)	(0.216)	(0.151)	(0.468)	(0.061)
	light H.	3.46	4.77	2.71	10.0	6.03	6.17	65.2	4.36	5.13	7.55
	liquid H.	0.824	18.8	3.31	10.9	12.7	33.8	7.19	1.35	6.35	0.42
	total H.	4.48	23.7	6.36	20.9	18.8	40.0	72.8	5.88	11.9	8.02
	C.B.A.	1.92	26.8	10.3	23.4	38.9	43.5	25.5	1.57	23.7	0.50
240	gas H.	(0.786)	(0.80)	(1.01)	(0.442)	(0.287)	(0.487)	(0.593)	(1.23)	(4.80)[a)]	(0.08)
	light H.	5.51	6.96	2.66	5.47	7.71	4.38	18.8	11.6	13.6	1.30
	liquid H.	0.972	18.1	4.30	15.5	12.4	39.0	8.10	1.47	2.55	0.46
	total H.	7.17	25.8	7.83	21.4	20.5	43.9	27.6	14.3	21.2	1.83
	C.B.A.	2.33	26.8	11.5	37.1	42.6	50.4	26.4	1.60	20.1	0.92
280	gas H.	(4.70)	(4.04)	(5.37)	(6.08)	(3.86)	(3.45)	(6.26)	(4.51)	(8.73)	(0.40)
	light H.	9.11	7.66	11.8	9.26	25.4	11.1[a)]	16.1	6.92	5.84	4.40
	liquid H.	1.42	21.7	7.82	57.6	20.8	73.6	22.2	1.28	64.9	0.75
	total H.	14.97	33.3	24.7	73.2	50.7	88.3	45.7	12.7	80.9	5.51
	C.B.A.	3.08	36.9	16.0	119.6	118.0	117.0	82.30	1.66	145.6	0.86
320	gas H.	(22.1)	(20.1)	(17.6)	(37.0)	(55.4)	(31.8)	(22.8)	(22.2)	(37.4)	(2.02)
	light H.	12.1	11.3	3.26	8.90	21.4	17.9	73.5	7.82	6.87	7.04
	liquid H.	1.57	12.2	8.86	87.70	40.3	278.9	69.8	0.32	377.4	0.72
	total H.	35.1	45.7	31.0	142.9	138.7	329.6	173.9	30.5	429.7	9.49
	C.B.A.	3.53	22.3	24.4	166.8	210.8	735.8	138.3	4.96	723.0	0.86
360	gas H.	(57.3)	(59.0)	(58.3)	(97.0)	(123.0)	(108)	(75.1)	(58.9)	(140.0)	(6.40)
	light H	11.7	13.5	11.3	10.5	28.5	42.4	90.0[a)]	13.0	66.8	13.8
	liquid H.	0.73	1.84	2.26	1.18	4.32	121.1	9.48	1.77	75.2	0.46
	total H.	62.2	73.3	68.5	114	153	282	199	69.3	321	19.3
	C.B.A.	1.64	7.04	9.57	2.96	15.6	160.8	16.6	4.34	105	0.70
400	gas H.	(98.6)	(122.0)	(164.0)	(224.0)	(246.0)	(335.0)	(182.0)	(120.0)	(350.0)	(29.5)
	light H	6.73	56.4	6.17	29.0	52.5	45.8	11.7	23.6	32.3	14.7
	liquid.H.	0.54	1.1	1.1	6.40	8.86	19.1	1.54	0.91	23.4	0.31
	total H.	84.7	160	143	244	280	427	209	119.5	463	36.7
	C.B.A.	2.7	2.8	1.7	17.5	21.1	36.6	1.54	2.42	52.8	0.31

Numerical unit in brackets is mL/g. a) Calculated value; b) gas H., gas hydrocarbon; light H., light hydrocarbon; liquid H., liquid hydrocarbon; total H., total hydrocarbon; C.B.A., chloroform bitumen A.

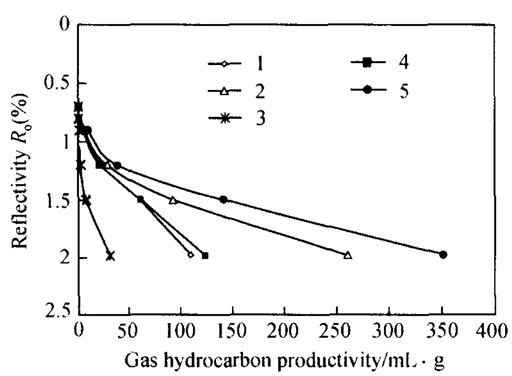

Fig. 1. The gas hydrocarbon productivity of some main macerals. 1, Vitrinite; 2, exinite; 3, inertinite; 4, desmocollinite; 5, alginite.

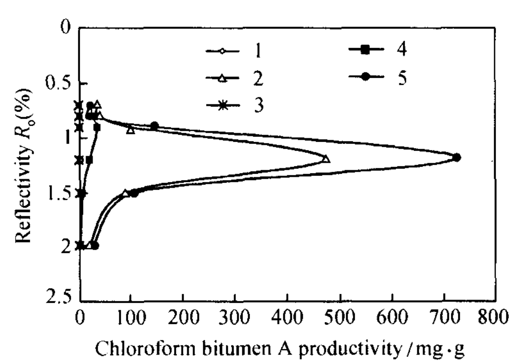

Fig. 2. The chloroform bitumen A productivities of some main macerals. Legends are the same as in fig.1.

G13 is the GHP of inertinite coal. In later illustrations of light hydrocarbon, chloroform bituminous, liquid hydrocarbon and total hydrocarbon productivity, counting and drawing methods are the same as in fig. 1.

(2) Light hydrocarbon productivity (LtHP). Changes of the LtHP of various coal samples are more complex (table 3), controlled by both experiment temperature and type of samples. Experimental results show the highest LtHP at 360℃. The LtHP of sporinite coal is the highest among 10 coal

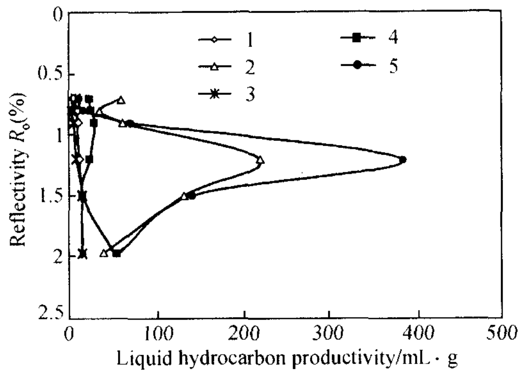

Fig. 3. The liquid hydrocarbon productivities of some main macerals. Legends are the same as in fig. 1.

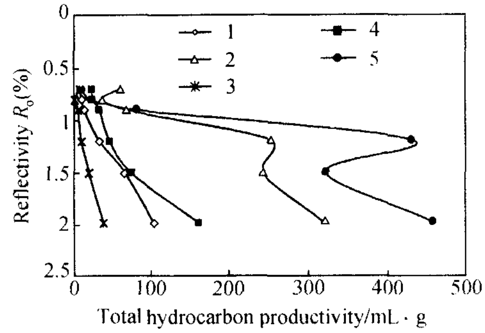

Fig. 4. The total hydrocarbon productivity of some main macerals. Legends are the same as in fig. 1.

samples and amounts to 73—90 mg/g at 320—360℃. Then the sequence of the LtHP is alginite > cutinite > suberinite > cannel > descomollinite. The LtHP of inertinite sample is slightly high, since fusain of the sample is filled by a little of exudative bitumen and more light hydrocarbons are conserved in cell structures of fusain.

(3) Chloroform bitumen A productivity. Only the highest chloroform bitumen A productivity of descomollinite is at 280℃, and that of other coal samples is at 320℃.

The sequence of chloroform bitumen A productivity of 10 coal samples is: cutinite (735.8 mg/g) > alginite (723 mg/g) > suberinite (210.8 mg/g) > cannel (166.8 mg/g) > sporinite (138.3 mg/g) > desmocollinite (36.9 mg/g) > humic coal (5.08 mg/g) > telocollinite (3.08 mg/g) > inertinite (0.86 mg/g), as shown in table 3. The change trend of chloroform bitumen A productivities of some main macerals in various evolution stages is shown in fig. 2.

(4) Chloroform bitumen A composition. Chloroform bitumen A composition of various coal samples is more complex and more different from each other. That aliphatic contents in chloroform bitumen A of desmocollinite and cutinite amount to 58.1%—49.35% at 200—240℃ shows that hydrocarbon generation of desmocollinite and cutinite is earlier .

Alkane content in chloroform bitumen A of cannel and alginite amounts to 43%—40.3% at 320—360°C, that of sporinite and telocollinite amounts to 33.1% and 16.6% at 320℃, separately. Chloroform bitumen A productivity of suberinite is very high, but its alkane content in chloroform bitumen at various temperatures is very low, lower than 10% normally. Alkane content in chloroform bitumen A of telocollinite is low, but aromatic content is high and that of suberinite is low too, but asphaltene content is high.

(5) Liquid hydrocarbon productivity (LdHP). The amount of alkane and aromatic from various samples is regarded as their LdHP. The highest LdHP of samples are commonly at 320°C: alginite, 377.4 mg/g; cutinite, 278.9 mg/g; cannel, 87.7 mg/g; sporinite, 69.8 mg/g; telocollinite, 1.57 mg/g. The highest LdHP of desmocollinite is 21.7 mg/g at 280°C. The LdHP of alginite and exinite are 55—240 times that of telocollinite and 5.6—13 times that of desmocollinite. The LdHP of humic coal and inertinite are very small. The LdHP change trend of some main macerals is shown in fig. 3.

(6) Total hydrocarbon productivity (THP). The amount of gas, light and liquid hydrocarbon productivities of various samples is regarded as the THP (table 3). The THP of sporinite amounts to 72.8 mg/g at low temperatures, higher than other samples. At medium and high temperature, the THP of alginite and exinite amount to 463—209 mg/g, that of desmocollinite and telocollinite 160—84.7 mg/g, and that of inertinite only 36.7 mg/g. The THP of hydrogen-rich coals are over 5 times that of hydrogen-poor coals. The THP change trend of some main macerals is shown in fig. 4.

3 Law and evaluation indexes on oil and gas generation of coal

(i) Law of oil and gas generation of coal. Gas and liquid hydrocarbons are generated from coal in the thermal evolution generally at the same time, gas is a main product only at high temperature owing to pyrolysis of oil to gas. It is a new exploration how to discuss oil and gas potentials of bituminous coal according to results from thermal simulations. In thermal simulations, the highest chloroform bitumen A productivity of coal is at 320℃, at which pyrolysis of oil to gas has not extensively arisen as yet. Therefore, oil and gas generation trend of various coals is discussed according to yields of oil and gas in thermal simulations at 320℃.

As shown in table 3 and fig.1, the GHP of telocollinite and humic coal at 320℃ amount to 60%—70% of the THP, the LtHP 34%—23% and the LdHP only 4%—1% of the THP, and the gas/oil ratio is 1.5—2, at 320℃. Telocollinite and humic coal are regarded as gas-generating coal.

The GHP of exinite, alginite and cannel coal at 320℃ amounts to 9%—32% of the THP, the LtHP 1.6%—44.9% of the THP and the LdHP 87%—40% of the THP, and the gas/oil ratio is 0.1—0.47, at 320℃. Therefore exinite, alginite and cannel coal are regarded as oil-generating coal.

The GHP of desmocollinite coal accounts for 49%—60% of the THP, at 320℃, the LtHP and the LdHP are only 24.7%—10% and 26.7%—28.6% of the THP, separately. The gas/oil ratio is 0.9—1.5, at 320℃. So desmocollinite coal belongs to oil- and gas-generating coal.

The hydrocarbon productivities of interinite coal are very low, the GHP is only 1.73 mg/g, the LtHP is only 7.04 mg/g and the LdHP is only 0.72 mg/g. Therefore inertinite coal is not regarded as hydrocarbon-generating coal.

The thermal experiments and analysis results show that the controlling factors in oil and gas generation of coal are mainly maceral compositions and hydrogen-rich level of coal. The higher the H/C ratio and contents of exinite, liptodetrinite, micro-lipids, alginite, asphaltenes and hydrogen-rich fluorometric desmocollinitein coal, the higher the total hydrocarbon productivity and the higher the oil potential of coal. But exinite and alginite contents in most seams are less, therefore nature and content of desmocollinite in coal are main controlling factors in oil and gas generation of coal. In addition, the total contents and relative ratios of methyl, methylidene and mehtylidyne in coal are more important factors, too. The more the alkyl content in coal, the higher the hydrocarbon yields of coal; the more the methylidene and mehtylidyne contents, the higher the oil potential of coal.

Besides macerals and sedimentary environment, types and degrees of coalification are very important influence factors on hydrocarbon potential of coal. Oil derived from coal is mainly generated in medium coalification—bituminous coal rank. The experimental results show that generating liquid hydrocarbon from desmocollinite has occurred in the early stage of bituminous rank.

In addition, the results show that the H/C ratio of humic coal not undergoing geological bituminization is not low, but the LdHP and THP are lower.

(ii) The evaluation indexes on oil and gas potential of bituminous coal. Experimental and analytical results show that there are main analytical items reflecting oil and gas potential of coal , but among them, S_1, S_2, HI, TOC in Rock-Eval analysis and H/C, R_o% are economic and practical indexes. S_1 was not regarded as independent index in evaluation on hydrocarbon potential of coal. According to analysis results of coal samples from the Tuha Basin and other areas, S_1 is a more important, but simple and easy, index in the evaluation on hydrocarbon potential of coal.

At present, a difficult problem of the evaluation on oil and gas potential of coal lies in definition of quanity of evaluation indexes, rather than selection of them. According to simulation experimental results and analysis data of coal samples from the Tuha Basin, hydrocarbon potential of coal is divided into five grades by four major indexes (S_1, S_1+ S_2, HI, H/C in table 4) and the information on oil and gas fields from coal [7,8,10,12-16].

Table 4 Evaluation indexes on hydrocarbon potential of bituminous coal

Grade	Excellent	Good	Medium	Poor	Bad
S_1 /mg • g^{-1}	>15	5—15	1—5	0.5—1	<0.5
S_1+S_2/ mg • g^{-1}	>230	120—230	60—120	30—60	<30
HI/mg • g^{-1}	>320	200—320	100—200	50—199	<50
H/C atom ratio	>1.1	1.1—0.8	0.6—0.9	0.4—0.6	<0.4

Excellent grade: Major oil-generating coal. In this kind of coal, contents of exinite and sapropelinite are very high (>30%). This kind of coal can generate a great quantity of liquid hydrocarbon in bituminous coal rank.

Good grade: Oil and gas-generating coal. In this kind of coal, contents of exinite and desmocollinite are higher (exinite content is 10%—30%). This kind of coal can generate both oil and gas in the medium evolution stage of coal.

Medium grade: In this kind of coal, the content of exinite is less than 10%, S_1 value is 1—5 mg/g. This kind of coal can generate gas and a little of oil in the thermal evolution.

Poor grade: This kind of coal is a semidull coal in which inertinite is mainly maceral and exinite content is very low. This kind of coal can generate a little of gas in the thermal evolution.

Bad grade: This kind of coal is a fusodurain in which inertinite content is very high and fusain is filled by very little exinite. In this kind of coal, S_1 value is less than 0.5 mg/g, S_1+S_2 less than 30 mg/g, HI value less than 50 mg/g, and the H/C ratio is less than 0.4. It is not hydrocarbon-generating coal.

The higher the thermal evolution of coal, the more the hydrocarbons derived from coal. The oil-generating coal in the medium evolution stage transforms into the gas-generating coal in the high evolution stage. In this stage gas productivity of hydrogen-rich and oil-generating coal is 3—5 times that of hydrogen-poor coal. Therefore coal-generated gas should be a focal point of exploration in the areas where the thermal evolution stage of coal strata is higher and conservative conditions are good. Coal-generated oil field and coal-generated gas field from coal and coal-measure source rocks can be found in the coal basin where contents of hydrogen-rich compositions are higher and thermal evolution stage of coal strata is medium.

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