



## ARTICLE

# Hydrocarbon Generation Potential Evaluation of Coal Shale Gas of Permo-Carboniferous in Jiyang Depression

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### ABSTRACT

In order to study the hydrocarbon-generating potential of Carboniferous-Permian coal shale in Jiyang Depression, geochemistry, petroleum geology and coal geology were applied to study the residual strata distribution of Carboniferous-Permian in Jiyang Depression, organic matter abundance, organic matter types and organic matter maturity of mudstone. The results show that the thickness of the Carboniferous-Permian residual strata in Jiyang Depression is generally 200-800 m, with a maximum thickness of 900 m; the organic matter abundance of coal-bearing shale is good, and it is type III kerogen, which is conducive to gas generation, and the maturity of organic matter reaches a mature-higher maturity stage; the hydrocarbon generation potential of Benxi Formation and Taiyuan Formation is better; Medium to good hydrocarbon source rocks is able to be found in every sag of Shanxi Formation hydrocarbon source rocks, but the scope is limited, and the overall evaluation is still medium. Generally speaking, the Permo-Carboniferous coal-bearing shale in Jiyang Depression has certain shale gas exploration potential.

## 1. Introduction

Shale gas refers to natural gas in dark mud shale, which is mainly adsorbed and free. Essentially, it is a continuous generation of biochemical gas, thermogenic gas or a mixture of both<sup>[1-3]</sup>. The formation and distribution of shale gas have unique characteristics. Shale gas often distributed in the effective source rocks with large thickness and wide distribution in the basin, which has the advantage of large resource potential and long exploitation life<sup>[4-6]</sup>. Conventional wisdom holds that source rock can only produce oil and gas but cannot store oil and gas. However, with the development of times, it is

gradually found that source rocks can not only generate natural gas but also store a large amount of natural gas<sup>[7-8]</sup>. Therefore, it is not too much to say that the formation of shale gas reservoirs is due to the adsorption of shale formation and hydrocarbon residue caused by low formation permeability<sup>[8]</sup>. However, cracks and voids in mud shale become the space where oil and gas occur, so a large part of the gas is retained in the mud shale stratum ("shale gas")<sup>[9]</sup>.

The Jiyang Depression is located in the south of the Bohai Bay Basin. Where the Carboniferous-Permian is relatively developed. A large number of dark shales are

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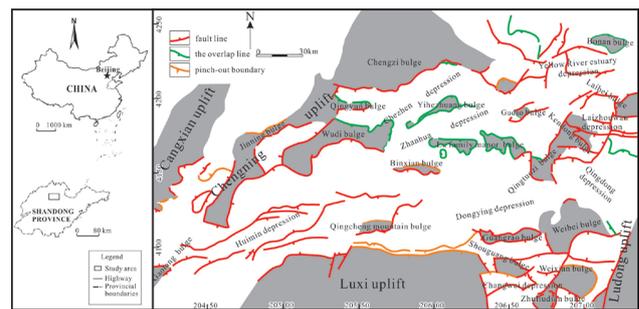
developed in Benxi Formation, Taiyuan Formation and Shanxi Formation, which are important source rocks because of their rich organic matter<sup>[10-13]</sup>. The Carboniferous-Permian sandstone reservoir in this area is object of exploration. Coal-derived gas from the Carboniferous-Permian coal-bearing source rocks was found in the Shihezi Formation sandstones<sup>[14]</sup>, but the research on coal-bearing shale gas was relatively less. In this paper, the hydrocarbon generation potential of shale in Carboniferous-Permian in Jiyang Depression is studied by geochemical method, and the shale gas resource potential is determined, which has certain guiding significance for shale gas exploration in this area.

The abundance of organic matter is used to represent the relative content of organic matter in rocks, and to measure and evaluate the hydrocarbon generation potential of rocks. At present, there are three indicators to measure: the total organic carbon content (TOC), rock pyrolysis hydrocarbon generation potential (S1+S2) and hydrocarbon index (HI)<sup>[7-8, 10-15]</sup>. The hydrocarbon generation potential of shale in the Benxi, Taiyuan and Shanxi Formations has studied in detail. Among them, the Benxi Formation and the Taiyuan Formation are products of the epicontinental sea environment, while the Shanxi Formation is the formation of the deltaic environment<sup>[25]</sup>. Therefore, combining with sedimentary environment, the hydrocarbon generation potential of Benxi Formation and Taiyuan Formation and Shanxi Formation is discussed in this paper.

## 2. Regional Geological Survey

Jiyang Depression is a first-order negative tectonic unit, which converges westward and spreads eastward near east-west direction and is hosted by Chengning uplift and Luxi uplift in Bohai Bay Basin<sup>[13, 18]</sup>. It is bounded by Chengning uplift in the north, Luxi uplift in the south, Bohai Sea in the East and Linqing block fault basin in the west<sup>[11-13]</sup>. The depression includes Chezhen, Zhanhua, Huimin and Dongying sags<sup>[16]</sup> (Figure 1). The Carboniferous-Permian system in Jiyang Depression is similar to the whole North China area. In the late Ordovician of Early Paleozoic, due to the influence of Caledonian movement, the whole uplift was denuded, and the deposits of Upper Ordovician, Silurian, Devonian and Lower Carboniferous were missing. From the Late Carboniferous, the North China Platform was re-subsided and deposited, and a set of coal-bearing strata of marine-continental interaction was formed in the Late Permian. There are two sets of obvious sedimentary assemblages: from late Carboniferous to Early Permian, Jiyang Depression is a large epicontinental sea basin like North China. It deposited a set of "sea-land alternating" coal-bearing strata, that is, the

main hydrocarbon-rich strata of Carboniferous-Permian. From early Permian to the end of Late Permian, Jiyang Depression is a large continental depression basin and has deposited a set of continental strata, which basically did not contain marine deposits and had poor coal-bearing property<sup>[17]</sup>. Thickness of the residual Carboniferous-Permian is generally 400-1000 m, and the maximum thickness is estimated to be about 1200 m. The thickness of dark mudstone and carbonaceous mudstone is 50-250 m. The maximum thickness of coal seam is 44.5m<sup>[18]</sup>. The coal-bearing strata in this area are Benxi Formation, Taiyuan Formation, Shanxi Formation, Lower Shihezi Formation and Upper Shihezi Formation<sup>[19-21]</sup>. Among them, Benxi Formation, Taiyuan Formation and Shanxi Formation are coal-bearing strata. The sedimentary environment of the Benxi Formation and the Taiyuan Formation is epicontinental marine environment, while the Shanxi Formation is formed in the river-controlled shallow water delta sedimentary environment<sup>[22]</sup>.

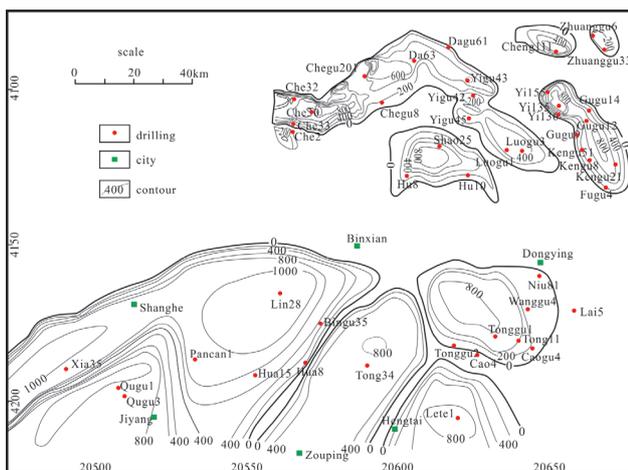


**Figure 1.** Geographical location map of the study area and tectonic unit of Jiyang Depression

## 3. Coal-bearing stratum distribution

Jiyang Depression is relatively complete. From Archean to Cenozoic, except for the lack of Upper Ordovician, Silurian, Devonian and Lower Carboniferous, the rest of the strata are distributed in<sup>[23]</sup>. Carboniferous-Permian source rocks are abundant, mainly coal and dark mudstone<sup>[24]</sup>. Drilling data have confirmed that the Carboniferous-Permian strata are distributed in every depression of Jiyang Depression<sup>[25]</sup>. Drilling into the Carboniferous-Permian wells is mostly distributed in the Zhanhua sag and Chezhen sag in the north, while in the Dongying and Huimin sags in the south, relatively few wells are drilled in the Carboniferous-Permian coal measures. The distribution limit of the residual carboniferous-Permian strata in this area is controlled by the NE-trending faults developed in the late Mesozoic, which have the characteristics of North-South zoning or subdivision. They mainly distribute along the north-east direction on the slope of each depression to the sag belt. From north to south, they

are Chexi-Dawang-Chengdong, Shaojia-Luojia-Gubei, Zizhen-Yangxin and Linnan. Lin Fanjia and Dongying Nanpo<sup>[26]</sup>. The coal-bearing strata of Carboniferous-Permian in Jiyang Depression are buried in depth of 500-7000 m, and the depth in most areas is 2000-6000m<sup>[14]</sup>. Residual thickness varies greatly in different locations. For example, the residual thickness in the southern and northern regions is generally 200-800m and the maximum thickness is 900m. According to the stratum thickness statistics of single well drilling, Qugu 2 well in Huimin sag has the largest stratum thickness, reaching 845 m, while Yigu 4 well in Zhanhua sag has the smallest stratum, only 9m. From the distribution of zones, the Chezhen Sag is mostly about 200m, with the maximum thickness of 642.5m (Chegu 31 well) and the minimum thickness of 25.5m (Chegu 11 well) (Figure 2); There are fewer Carboniferous-Permian drillings in Zhanhua sag, mainly concentrated in Shaojia-Luojia area, with the maximum thickness of 746 m and the minimum of 118 m. In the Dongying Depression, there are few exploration wells in the Carboniferous-Permian, and the distribution is uneven. The maximum drilling thickness is 623m, and the minimum is 23m; the maximum drilling thickness in Huimin sag is 845m and the minimum is 168m. According to the statistics of the drilled coal seam and the dark mudstone, the thickness of the coal seam is between 14-29 m, and the dark mudstone thickness is about 260 m.



**Figure 2.** Stratum isopach map of Permo-Carboniferous in northeast of Jiyang Depression

## 4. Organic Geochemical Characteristics of Mud Shale and Evaluation of Source Rocks

### 4.1 Abundance of Organic Matter

Organic carbon (TOC) is the basis of hydrocarbon generation, and is also one of the important parameters re-

flecting the abundance of organic matter in shale<sup>[27]</sup>. It is also a key parameter for evaluating the source rock's gas generating capacity and gas production<sup>[28]</sup>. If the content of organic carbon is high, the ability of shale to generate hydrocarbon is strong, which mean that there are enough parent materials to generate hydrocarbons<sup>[29-30]</sup>. Hydrocarbon generation potential refers to the maximum amount of organic matter in a unit source rock that is able to be converted into hydrocarbons under natural geological conditions, usually expressed as S1 + S2. S1 indicates hydrocarbons that have been generated but not discharged from rocks, also known as residual hydrocarbons, and S2 indicates organic matter that is able to be generated but has not yet generated hydrocarbons in rocks<sup>[31]</sup>.

### 4.1.1 Organic Matter Abundance of Benxi Formation and Taiyuan Formation

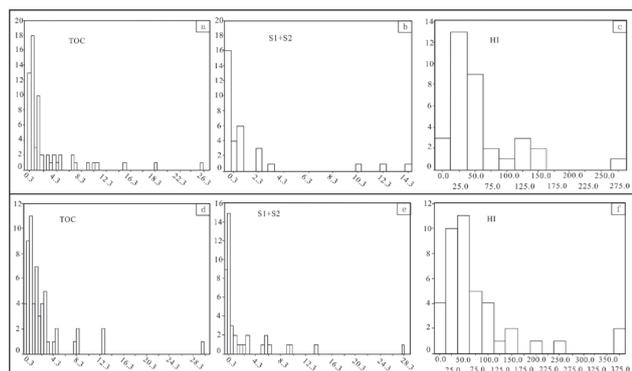
Most of the mudstones of Benxi and Taiyuan Formations in Dongying Depression have TOC less than 1.5%, S1+S2 less than 0.6 mg/g, and TOC and S1+S2 values in carbonaceous mudstones are higher, HI is 10-100, which generally belongs to poor gas source rocks.

The TOC of shale in Huimin Depression is generally 0.5% ~ 2.5%, and S1+S2 is generally 1 mg/g, up to 14.66 mg/g, generally medium-poor gas source rock.

Mudstones in Zhanhua sag are generally moderate to better gas source rocks. TOC in mudstone is generally greater than 1%, S1+S2 is mostly 0.5 ~ 4 mg/g, HI is lower, generally less than 100. Regionally speaking, TOC of Carboniferous in Luojia area is 0.6% ~ 1%, S1+S2 is basically less than 0.5%, and most of them are medium-poor gas source rocks with a Ro of 4% (Table 1). In the Yihezhuang area, the TOC of shale is generally 1% ~ 6%, S1+S2 is generally 1mg/g, the maximum is 15.32mg/g, and the maturity Ro is 0.8 ~ 1.35. It belongs to medium-good Source rock. The TOC of the Carboniferous mudstone in the Gubei area is high, ranging from 5% to 8%, and the maturity of Ro is 1.5% to 1.8%. It belongs to better gas source rock. (Table 1).

According to TOC, S1+S2, and HI frequency analysis, the TOC of mudstones in Benxi Formation and Taiyuan Formation is less than 4%, and the concentration distribution range is between 0.6% ~ 4%, which is medium-poor gas source rock (Figure 3). Among them, TOC was mainly 0.6%~1.5%, accounting for 49%, and the maximum peak value was 0.8%. S1+S2 is less than 3 mg/g, accounting for the vast majority, and is evaluated as medium-poor gas source rocks. The peak values of Benxi and Taiyuan Formations are about 0.1 mg/g, while those of Shanxi Formation are slightly better, about 0.6 mg/g. The HI is less than 100, and the medium-good source rock is about 40%. The

overall assessment is medium-poor gas source rock. At the same time, the study also reveals that the mudstones of the Benxi and Taiyuan Formations are generally better in the north than in the south, while Dongying, Huimin, Chezhen and Zhanhua are better in turn (Table 1).



**Figure 3.** Frequency map of TOC S1+S2 HI of mudstones of Benxi and Taiyuan (a, b, c) 、 Shanxi (d, e, f) Formations in Jiyang Depression

**Table 1.** Geochemical characteristics of mud shale in Jiyang Depression

Position	Region	TOC%	S1+S2mg/g rock	HI	Maturity Ro	Evaluation
Benxi formation and Taiyuan formation	Dongying	<1.5	0.6	10-100	0.7-2.4	poor
	Huimin	0.5-2.5	0.3-1.5	40-60	0.8-2.2	middle-poor
	Zhanhua (Luoja)	0.6-1	<0.5	<40	4%	poor-middle
	Zhanhua (Yizhuang)	1-6	1-15.32	<100	0.8-1.35	middle-well
	Zhanhua(Isolated north)	5-8			1.5-1.8	preferably
Shanxi formation	Dongying	1.21-30.81	0.51-10.33	<100	1.0	middle-preferably
	Huimin	0.5-2.5	<1.5	30-60	1.1	middle-poor
	Chezhen				0.9	middle-preferably
	Zhanhua(Isolated north)	>1			maturity - migh maturity	middle-preferably
	Zhanhua (Isolated north)	0.8-3				middle

### 4.1.2 Organic Matter Abundance in Shanxi Formation

Carbonaceous mudstones are developed in Permian in Dongying Depression, with high TOC content ranging from 1.21% to 30.81%. TOC of carbonaceous mudstones is generally greater than 10%. S1+S2 is generally greater than 3 mg/g. Therefore, carbonaceous mudstones of Dongying Depression

in Permian is a medium-fine gas source rock. (Table 1).

Permian TOC in Huimin sag is mainly 0.5%~2.5%, accounting for 70%. Grade distribution of effective gas source rocks: TOC mass fraction is less than 0.6%, accounting for 10%; TOC mass fraction is 0.6%~1.5%, accounting for 38%; TOC mass fraction is 1.5%~4.0%, accounting for 43%; TOC mass fraction is more than 4%, accounting for 9%. The hydrocarbon generation potential is mainly less than 1.5 mg/g, accounting for 88%. HI distributes mainly in the range of 30~60. The overall evaluation is medium-poor gas source rock (Table 1).

The Permian mudstones in the Chezhen sag has only been analyzed in Well Da 51, which is a medium-good gas source rock, slightly better than the underlying Carboniferous system (Table 1).

The TOC distribution area in Zhanhua sag is relatively wide, ranging from 0.5% to 6%, and S1+S2 is generally less than 2 mg/g. The evaluation is mainly medium gas source rocks. Each area in Zhanhua sag are different. The TOC of Permian mudstones in the Gubei area is generally more than 1%, with a maximum of 5.19%, and the maturity is also high. The peak temperature of pyrolysis is generally above 450°C and the highest temperature is 540°C. It is in the mature-high maturation stage. So most of them belong to medium-better gas source rocks. Among them, 54% are medium gas source rocks, better gas source rocks account for 15%, and the rest are poor gas source rocks. TOC in Gunan area is 0.8%~3%, which belongs to medium gas source rock (Table 1).

Generally speaking, the regularity of hydrocarbon source rocks in Shanxi Formation is not as good as that in Benxi Formation and Taiyuan Formation. Although medium-good hydrocarbon source rocks is able to be found in each depression, their scope is limited(Table 1).

Through TOC, S1+S2, and HI frequency analysis, it was found that TOC of source rocks in Shanxi Formation is generally less than 4%, and the main distribution range is 0.6%~4%. The peak value ranged from 0.6% to 1.5%, accounting for 37%. The distribution of S1+S2 is generally less than 4 mg/g and concentrated in the range of less than 1 mg/g. Among them, 22% were S1+S2 less than 0.5 mg/g, 43.9% were S1+S2 0.5-1.0 mg/g, and only 34% were others. The distribution of HI is generally less than 100. The proportion of medium- good source rock is about 40%, and that of poor source rock is about 50%. The overall evaluation is medium to poor source rocks.

### 4.2 Organic Type

Zhang Shanwen et al. [32] found that the whole background of the Bohai Bay Basin in the depositional period of the Benxi and Taiyuan Formations is the organic sedimentary facies of the shallow marsh forest, and that there were nearly East-

West marsh forest sedimentary organic facies in the northern part of Jiyang Depression. During the sedimentary period of the Shanxi Formation, the Bohai Bay Basin developed mainly in the environment of delta, lagoon and tidal flat. The organic facies of shallow marsh forest deposits decreased significantly. The organic facies of terrestrial forest deposits developed in the northern part of Jiyang Depression and the organic facies of terrestrial forest deposits developed in the southern part of Jiyang Depression, while the organic facies of other deposits decreased significantly compared with Taiyuan formation, and the distribution range also decreased significantly. It is able to be concluded that the sedimentary organic facies of the Taiyuan Formation coal is much richer than that of the Shanxi Formation, and the hydrocarbon generation potential of the Taiyuan Formation coal is obviously better than that of the Shanxi Formation, and the matrix vitrinite and the crust composition of the Taiyuan Formation coal is better than that of the Shanxi Formation. The distribution map of organic elements in Jiyang area has been made. It is able to be found that the main type of organic matter in Carboniferous-Permian source rocks in Jiyang Depression is type III kerogen (Figure 4), which is mainly gas-generating source rocks.

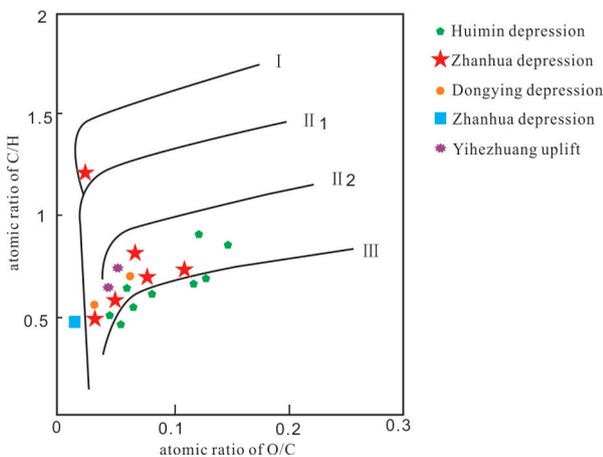


Figure 4. Organic elements distribution of coal series in Jiyang Depression

Table 2. Coal series maturity of Permo-Carboniferous in Jiyang Depression

region	depth (m)	Ro (%)
Chezhen-Dawangzhuang	2000-4000	0.62-0.72
Zhanhua Yidong	2000	0.63-0.9
Chezhen Zhuangxiqianshan	3500-4000	0.75-0.84
Zhanhua Isolated north	3700-5000	0.98-1.77
Zhanhua Island - Isolated north	2000-3100	0.65-0.87
Chezhen Luojia	3000-3400	1.18-1.48
Chezhen Wangpan town	2400-2700	0.75-1.05
Chezhen Qudi town	2400-3600	0.85-1.3

### 4.3 Organic Maturity

The maturity of organic matter plays an important role in shale gas formation. When the maturity is low ( $Ro < 0.6\%$ ), shale gas is mainly biogenic gas, or secondary biogas<sup>[33-34]</sup>, which is formed by the biochemical decomposition of freshwater leaching after shallow burial. Biogenic gas and pyrolysis gas will be formed at the same time, and they are mixed shale gas with high and low maturity. When the maturity is high ( $1.1\% < Ro < 2.0\%$ ), the shale gas mainly comes from the pyrolysis of organic matter and hydrocarbons, which is high maturity shale gas. When the thermal evolution degree of shale reaches over mature stage ( $Ro > 2.0\%$ ), shale gas is mainly dry gas of hydrocarbon pyrolysis.

The distribution of organic matter maturity RO of Carboniferous-Permian in Jiyang Depression is quite different, ranging from 0.6% to 5.16%. On the bulge and slope, the maturity of gas source rocks varies significantly among different regions. The Checheng-Dawangzhuang area has the lowest maturity, and the 4000m only reaches mature stage. In some areas, the maturity is high. For example, Gubei in Zhanhua, Luojia and Qudi in Chezhen, the maturation degree is higher, and Ro reach mature-high mature stage, which is related to the depth of burial (Table 2). From a flat point of view, the distribution trends of maturity of the Taiyuan Formation and the Shanxi Formation in the Bohai Bay Basin are consistent (Figure 5 and Figure 6). The Dongying sag is the main body, and the center of Zhanhua sag and Huimin sag are the high maturity centers, which distribute in a circular belt. Dongying sag is mainly in the high mature stage, Zhanhua sag and Huimin sag are mainly in the middle and late mature stage, while the western part is still in the mature stage.

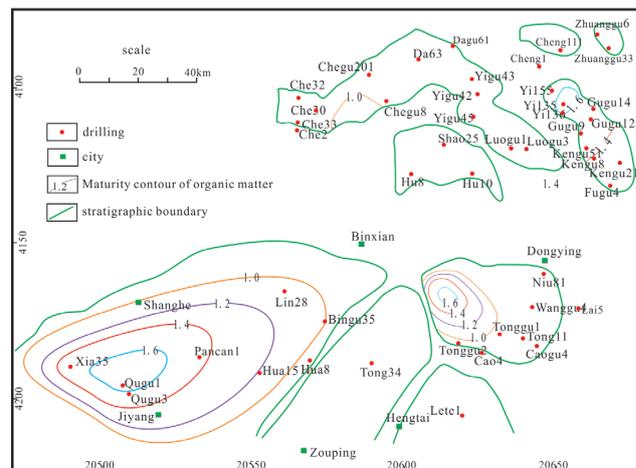
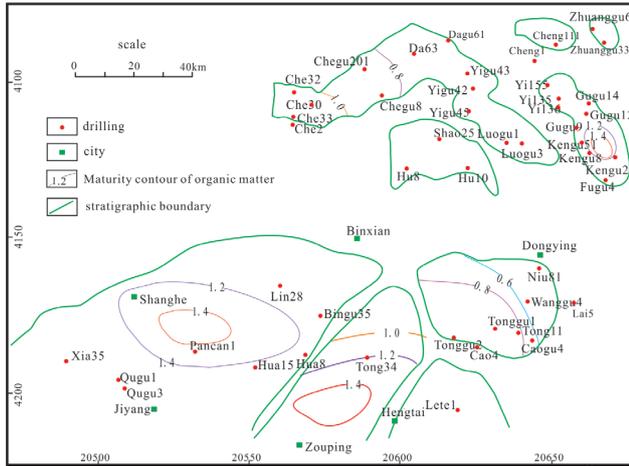


Figure 5. Contour line of organic matter maturity of Benxi and Taiyuan Formations



**Figure 6.** Contour line of organic matter maturity of Shanxi Formation

## 5. Comparison of Hydrocarbon Generation potential of coal-bearing shale gas in Jiyang Depression

### 5.1 Stratigraphic Distribution Comparison

Compared with the large Carboniferous-Permian coal-forming gas fields (Suqiao-Wen'an, Dongpu and Wuqing) discovered in North China, the coal-bearing strata in Jiyang Depression are widely distributed, reaching 8700 km<sup>2</sup>, second only to the Ordos Basin and the southern part of North China, but their stratigraphic continuity is poor. The stratum thickness is 200-800 m and belongs to the medium thickness stratum. Thus, the coal-bearing stratum conforms to the distribution characteristics of the existing Carboniferous-Permian coal-formed gas fields (Table 3).

### 5.2 Comparison of Shale Distribution and Maturity

The thickness of dark mudstone in Jiyang Depression ranges from 40 m to 100 m, with a maximum of over 300 m, and the thickness varies greatly. Most shales are buried in the depth of 900-8000 m, but generally more than 3 000 m, which belongs to the deep buried area. The maturity of shale is 0.6%~1.3%, which is lower than that of Dongpu, southern North China and Ordos Basin, but similar to that of Suqiao-Wen'an. In general, the shale in Jiyang Depression is deeply buried, and its maturity is similar to that in other depressions (Table 4).

### 5.3 Comparison of Shale Abundance

The organic matter abundance of the Carboniferous-Permian mudstones in Jiyang is at a medium level. TOC of

shale is 0.5%~30.81%, which is generally greater than 1%. The hydrocarbon generation potential is 0.3-116.09 mg/g. Compared with other basins, the organic carbon content of mudstone in Jiyang Depression is in the middle level, and the hydrocarbon generation potential is relatively high, slightly lower than the Ordos Basin. Therefore, the Jiyang Depression has a certain potential for hydrocarbon generation in shale (Table 5)

**Table 3.** Mud shale characteristics of main gas field in our country

region	formation thickness (m)	distribution area (km <sup>2</sup> )	distribution
Jiyang <sup>[14]</sup>	200-800	8700	part
Suqiao-Wenan <sup>[14]</sup>	700-1000	4564	part
Dongpu <sup>[14]</sup>	700-1000	5300	part
Wuqing <sup>[14]</sup>		2560	part
Southern north China <sup>[35]</sup>	600-900	31000	Part
Ordos Basin <sup>[36]</sup>		245800	continuous

**Table 4.** Mud shale characteristics of main gas field in our country

region	General mud shale thickness (m)	Maximum shale thickness (m)	cover depth(m)	maturity Ro(%)	Gas reservoir conditions
Jiyang <sup>[25]</sup>	50-100	300	900-8000	0.6-1.3	gas show
Suqiao-Wenan <sup>[25]</sup>	200-400	400	2600-4500	0.5-1.3	proven reserves 209×10 <sup>8</sup> m <sup>3</sup>
Dongpu <sup>[25]</sup>	100-160		1500-6000	0.8-2.0	proven reserves 480×10 <sup>8</sup> m <sup>3</sup>
Wuqing <sup>[25]</sup>	48-284		>3000	0.64-1.06	industrial gas flow
Southern north China <sup>[35]</sup>	300-400	600	1000-9000	0.8-3	
Ordos Basin <sup>[36]</sup>	60-200	200	600-5000	>2.0	Large gas fields

**Table 5.** Mudshale characteristics of main gas field in our country

region	organic carbon %	HI	S1+S2(mg.g-1)
Jiyang <sup>[25]</sup>	0.5-30.81	30-100	0.3-116.09
Suqiao-Wenan <sup>[25]</sup>	0.1-26.9		0.02-77.9
Dongpu <sup>[25]</sup>	0.1-39.8		0.17-76.26
Wuqing <sup>[25]</sup>	0.1-38.8		0.02-82.06
Southern north China <sup>[35]</sup>	0.38-33.93	8.5-223.3	0.1-77.17
Ordos Basin <sup>[36]</sup>	0.05~23.38	212-266	94.7-204.1

In summary, compared with the shale characteristics of the main Carboniferous-Permian coal-formed gas fields

in China, the hydrocarbon generation capacity of the Carboniferous-Permian coal-formed shale in Jiyang Depression is generally at a medium level, slightly higher than that in Puyang and South North China Basins, and has certain shale gas exploration potential.

## 6. Conclusion

(1) The Carboniferous-Permian residual strata in Jiyang Depression are thinner in the north and thicker in the south. The residual thickness is generally 200-800m, and the drilling thickness is up to 900 m. Due to the impact of the Mesozoic-Cenozoic fracture, the distribution of the Carboniferous-Permian strata in the northern part of Jiyang Depression is more obvious, and mainly distributed along the slopes of the sag to the sub-sag in the NE direction, and is distributed on five regional tectonic belts, from north to south, respectively for Chexi - Dawang - Chengdong, Shaojia - Luojia - Gubei, Zizhen - Yangxin, Linnan - Linfanjia, Dongying South Slope.

(2) Carboniferous-Permian coal rocks belong to better hydrocarbon source rocks. Type III kerogen of organic matter is conducive to gas generation. The maturity of organic matter reaches a mature-higher maturity stage and has the material basis for coal-bed methane generation. There are differences in the hydrocarbon generation potential of mudstones: Benxi Formation and Taiyuan Formation have better hydrocarbon generation potential in the northern part of the basin, that is, Dongying, Huimin, Chezhen and Zhanhua that become better in turn. And the regularity of hydrocarbon source rocks of Shanxi Formation is weaker than that of Benxi Formation and Taiyuan Formation. and medium-good hydrocarbon source rocks is found in each depression. However, the range is limited, and the overall evaluation is still moderate.

(3) Compared with other areas in China, the coal measures in Jiyang Depression are widely distributed and moderately thick. The organic matter abundance of Carboniferous-Permian mudstone is in the middle level, and the Carboniferous-Permian mudstone has certain hydrocarbon generation potential and exploration potential.

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