
The reservoir properties and distribution of Paleogene formation in the group of small and medium fault basins, on the periphery of eastern Songliao Basin

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Abstract

With the increase of the exploration and development in Songliao basin, in order to guarantee the high-efficient steady and increasing production of Daqing oil Field, and to seek advantageous positions to replace, we conduct a study of reservoir physical property and regularities of distribution of small and middle graben basin located in the eastern periphery of Songliao basin, combined with many regional geological data, geophysical data, well drilling data, oil and gas geological data and the experience of exploration during the exploration and development process of it for all these years. We analyze the composition, content, particle structure, cementation types and the variation law of porosity and permeability of paleogene clastic rock within the basin groups, summarize the basic geological data, in order to provide favorable geological basis for further oil and gas exploration.

Keywords

Fault basin group, Paleogene, Reservoir properties, Songliao basin

1. Introduction

The research area includes east of Yi-Shu graben and north of Songliao basin, which is located in Heilongjiang Province, Jilin Province and the eastern part of Liaoning province. Area of the four geographic coordinates are 127 °25 'E 50 °03 'N, 120 °58 'E 38 °41 'N, 135 °5 'E 48 °27'N, 135 °5 'N 48 °27'E. The physical features of area is high in the west and low in the east, high in the north and low in the south. The plains and mountains are approximately NNE to extend, and alternate arrangement. From the west to the East is the Xiaoxing'anling, Zhangguangcailing, Changbai mountain and Sanjiang plain. The main development of the rivers are Heilongjiang, Songhua river, Wusuli river, Tumen river and Suifen river[1-2].

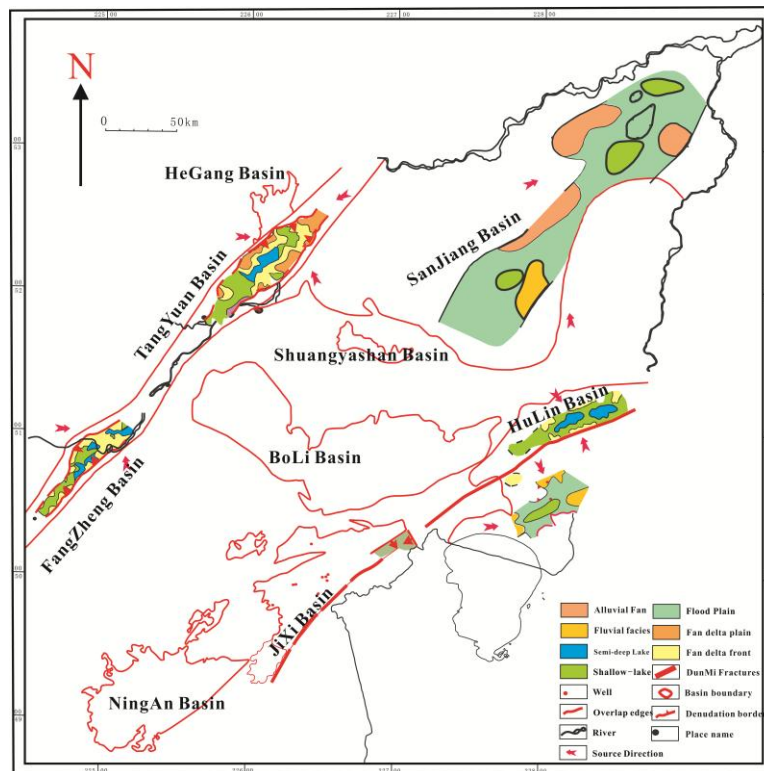


Fig.1.Paleogene sedimentary basins in the north east during the paleogeographic sketch

In the Paleogene period, due to the subduction of the Pacific plate from the direction of north east to turn NWW, in the northeast region Paleogene rift along the main NNE-trending deep faults. Tangyuan, Fangzheng, Chaluhe, Luxiang and Moliqing fault depression are most developed in the Yilan-Yitong fault zone. The formation and the thickness of them are large, and they are the products of the fault basin, which are controlled by normal faults, but Paleogene stratigraphic distribution less in other area. Sanjiang Basin mainly developed swamp, fan delta, fluvial, including fan delta plain distributed in northeast and the northwest edges, fluvial facies distributed in the southeast side, swamp distributed in the central and other regions, sporadic development of lakeshore-shallow lake subfacies. The area of Shuangyashan Basin and Boli basin were affected by tectogenesis, uplift raised to provide source for Sanjiang basin of their northeast, Tangyuan fault depression of their northwest, Hulin basin of their southeast. Hulin basin in northwest provenance accepted also by Dunmi fracture control. Hulin basin is divided into two northern and southern depression. Development of the northern basin margin fan delta front, to the gradual development of the central basin shallow lake and semi-deep lake subfacies (Fig.1)

South of the basin northwest accepted provenance, from the edge to the center of the basin, followed by the development of fluvial, swamp, shallow lake subphase. Jixi basin accept only a small portion of the area during the deposition by Dunmi fracture secondary faulting affected mainly developed swamp. In Yilan - Yitong fault zone nearby, the Tangyuan rift fault by two large role, accepts three directions northeast, southwest and west of the source material supply, margin mainly developed fan delta plain and lacustrine phase, to followed by the development of the central basin fan delta front, shallow lake and semi-deep lake phase. Tangyuan rift basin south of Shuangyashan, Boli Basin, Jixi Basin, Ning Tangyuan rift basin and the northern part of Area Hegang basin in Paleogene period uplifted surface weathering and erosion, not to accept deposits. In the region west of the Rift Founder, accept the regional impact from the south to the north was the source of supply and the western provenance, faulted fan delta front edge of the development phase, followed by the center to accept the rift lake shore shallow, half deep Asian lake sediments. In the Paleogene period, the northern part

of the study area warm and humid climate, in accordance Shu graben, Dunmi Dunhua basin and lake basin are mainly developed with dark mudstone and oil shale[5-13].

2. Petrological characteristics of the Palaeogene in the basins

According to M.T.H abouty (1979) for sedimentary basin is defined in a certain geological period, in the geographical area of the independent, in relatively unified tectonic environment, from more than one place or sedimentary rock composed of sediment source of sediments[3-4]. To study sedimentary basin in the area is divided into containing Sanjiang, Boli, Jixi, Ning'an, HuLin, Yanji, Dunmi etc., such as the 31 sedimentary basin in mesozoic and cenozoic (Fig.2).

2.1 Paleogene reservoir clastic composition and content

With reference to the current Chinese petroleum rock thin section identification standard of SY/T 5368-2000, we conducted a microscopic identification. Research area of the middle and small fault basin group clastic reservoirs were mainly distributed debris arkose ,except arkose and debris arkose in Moliqing and Chaluhe fault depression ,feldspar-quartz sandstone and arkose-debris arkose in Luxiang fault depression, and debris arkose-lithic sandstone in Hulin fault depression. Since quartz weathering strong, both anti-wear and difficult to break down (Zhu Xiaomin,2008). [1]

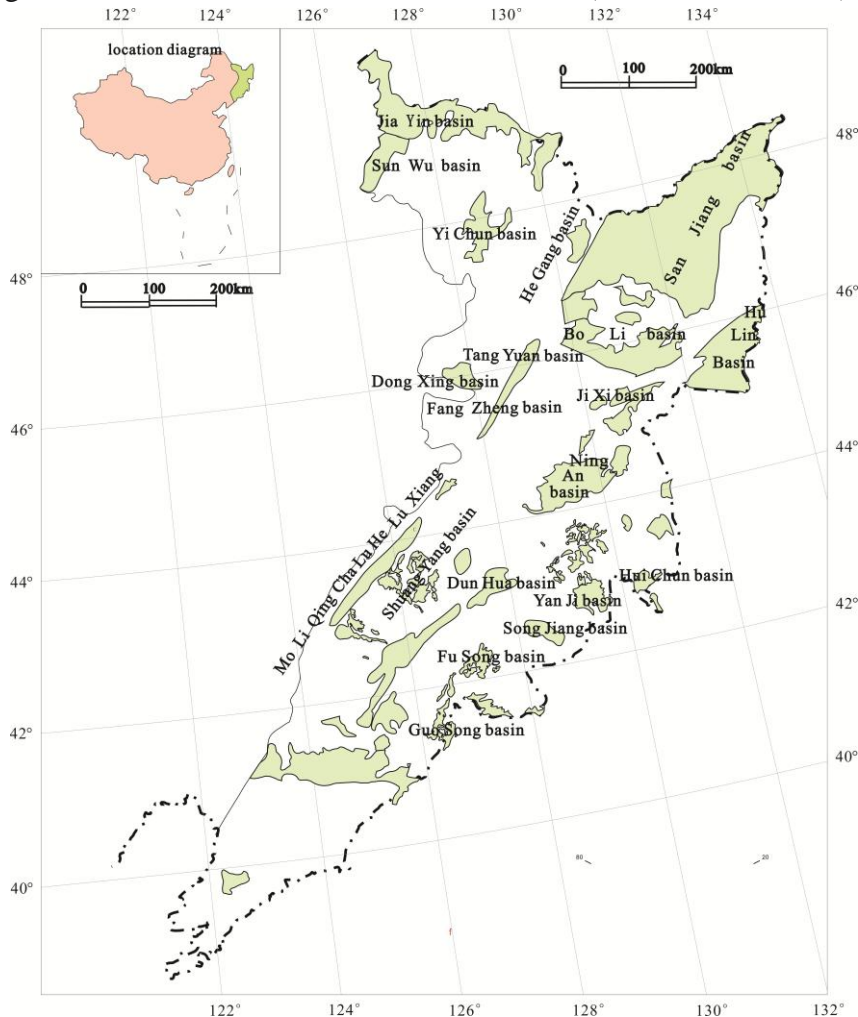


Fig.2.Songliao basin peripheral distribution of sedimentary basins to the east

The reservoir of Fangzheng fault depression in Yilan graben and Moliqing, Luxiang, Chaluhe fault depression in Yitong graben were with the high quartz content of rigid particles, while other fault basins were with the low quartz content of rigid particles. The reservoir of the lower is weak resistance to compaction, prone to dissolution of feldspar and lithic content is higher, easy to form solution pores, favorable to the increase of porosity and permeability. General speaking, the study area from northeast

to southwest, feldspar content increased, lithic content decreases. The basins of the northeast region are mainly debris arkose, the southwest area is mainly arkose and debris arkose. (Table.3).

2.2 Clastic particle size and structure of separation

Clastic particle size and structure of separation is one of the measures of the capacity and efficiency of carrying capacity[3-4]. The size of clastic particles determines the type and nature of the rock, and it is an important basis for the classification and nomenclature of clastic rocks (Table.4). So it is very important for us to study on the clastic particle size and structure of separation in the palaeogene fault basins.

Table.3 Statistical table of clastic content in the paleogene basins

Basin	Content	Feldspar (%)	Quartz (%)	Rock debris (%)
TangYuan Fault		42~68	10~30	22~26
FangZheng Fault		23~47	32~56	10~30
HuLin Basin		2~39	15~30	67~85
JiXi Basin		23~30	38~60	5~32
BoLi Basin		24~25	42~52	24~30
HunChun Basin		30~70	12~14	16~58
Moliqing Fault		4~96	5~41	22~38
Chaluhe Fault		0~80	5~54	10~27
Luxiang Fault		5~78	3~58	8.5~24

Table.4 Particle size classification of clastic

THE DECIMAL SYSTEM		THE BINARY SYSTEM		
PARTICLE DIAMETER mm	GRAIN SIZE DIVISION			PARTICLE DIAMETER mm
>1000	BOULDER	CONGLOMEATE/ BRECCIA	BOULDER	>256
100~1000	COBBLE		COBBLE	64~256
10~100	PEBBLE		PEBBLE	4~64
2~10	GRANULE		GRANULE	2~4
1~2	GIANT SAND	SANDSTONE	VERY COARSE SAND	1~2
0.5~1	COARSE SAND		COARSE SAND	0.5~1
0.25~0.5	MEDIUM SAND		MEDIUM SAND	0.25~0.5
0.01	FINE SAND		FINE SAND VERY FINE SAND	0.125~0.25 0.0625~0.125
0.05~0.1	COARSE SILT	SILTSTONE	COARSE SILT	0.0312~0.0625
0.005~0.05	FINE SILT		FINE SILT	0.0156~0.0312
			VERY FINE SILT	0.0078~0.0156
			SILT	0.0039~0.0078
<0.005		CLAYSTONE	CLAY	CLAYSTONE

Clastic particle size of the Sanjiang, Boli, Jixi Basin and Tangyuan, Fangzheng fault depression near Yilan fracture, which are located in the northern part of study area, is between 0.25-1.0mm. They are mainly filled of coarse sand and medium sand, except the part of area is with little granule and fine sand. The separation is medium to poor in common and the psephicity is showing angular and semi-angular. The reason is that the basins of the northern part is mainly affected by the Yilan - Yitong fracture, Mudanjiang fracture, Dunmi fracture, Dahezhen fracture. They are fault basins controlled by the deep fractures. They are near source sedimentary clastic particles because the moving distance is short. So it shows us large clastic size, poor sorting and rounded.

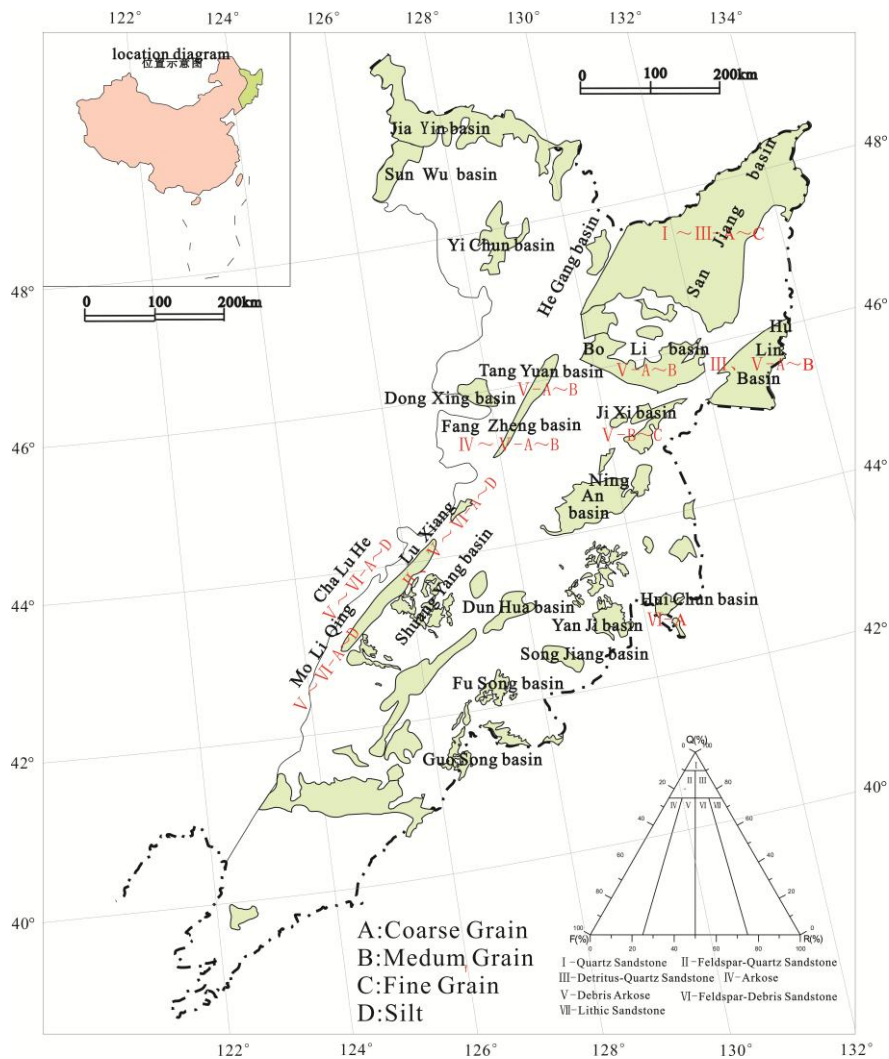


Fig.5 The composition and content of eastern basin group in Paleogene

The size of the paleogene clastic rocks in the southern area is generally low. The clastic particle size is about 0.01 to 0.5mm in Hunchun basin, it is mainly filled of fine sand and medium sand, sorting is medium to well, the majority of the roundness is semi-angular. Clastic rock maturity is low. The paleogene clastic particles sandstone of the Yitong graben, Moliqing, Luxiang and Chaluhe fault depression, which is located in the southwest side of the study area, is filled of medium sand and fine sand, and sometimes we can see sandy conglomerate and silt in the rock thin section. Their sorting features is mainly in the medium, and the medium- well is also can be seen. The psephicity is mainly semi-angular and some clastic strata structure reached sub-rounded. In general, the particle diameter of the basins in paleogene is relatively decreasing trend from north to south in the study area, Clastic structure changed for the better sorting, and the trend is roundness increased and maturity of clastic rocks rising from north to south (Fig.4).

2.3 Composition and content of the Paleogene clastic reservoir matrix

Matrix base content and character can reflect the handling flow properties of medium, reflect the sorting characteristics of the clastic component, is an important symbol of clastic structure maturity [3-4]. The matrix in the northern part of Jixi and Boli basin is hydro mica mudstones and the cements are mainly for the authigenic clay mineral, such as illite, calcite and laumontite. The matrix in Hulin basin is mainly claystone. Cement content is about 5% ,composition mainly calcite and micritic siderite. The matrix of Tangyuan and Fangzheng fault depression, which is in the north of Yilan-Yitong fault zone, is about 35%.content is about 35%.It shows that the grading function of the sedimentary environment is not strong, and the sediment has not been fully differentiation and transformation, thus different granularity of mud and sand mixed. While the matrix of the Moliqing, Luxiang and Chaluhe fault depression, which is in the south of Yilan - Yitong fault zone,are consist of claystone. Their content change between 1% - 13%, mainly for mud cementation, some strata for carbonate cementation and secondary kaolinite. In general, in the small and medium eastern fault basin group of the paleogene clastic fillings dominated by clay, and their content change is bigger. Northern area content is relatively high, some areas even reached 35%, the southern regional content is relatively low, less than 15%.

3. Reservoir porosity and permeability distribution

Reservoir is one of the basic elements of hydrocarbon accumulation necessary. Horizon reservoir, type, development characteristics, internal structure, distribution and physical properties of variation, is controlled underground oil and gas distribution and the important factor in oil reserves and production capacity. The porosity and permeability are two basic characteristics of the reservoir, the reservoir is a measure of the quality of reservoir properties of the basic parameters[3-4]. According to Chinese oil industry existing porosity and permeability criteria for the classification (SY / T 6285-2011) (Table 1-5), we porosity and permeability data analysis and statistics.

Paleogene reservoir average porosity of Sanjiang Basin, which is in the north of the study area was 28%, permeability of $353 \times 10^{-3}\mu\text{m}$, reservoir properties of high porosity and medium permeability. Located in the south of Tangyuan fault depression, Founder faulted, Hulin basin, Jixi basin, with an average porosity are mainly distributed in the 10.759-22.707%, 11.93-25.2%, 21.235%, 3.6-29.7%, the reservoir properties is mesoporosity, and a small portion of the formation appear high or low porosity. The average permeability of major distribution $(106.66-396.86) \times 10^{-3}\mu\text{m}$, $(305-4709) \times 10^{-3}\mu\text{m}$, $258.295 \times 10^{-3}\mu\text{m}$, $0.91 \times 10^{-3}\mu\text{m}$, mainly in the medium permeability, some of the Fangzheng formation is high permeability, but the overall performance of Jixi basin is ultra-low permeability. The Dunhua basin is with an average porosity of 24.8% and Hunchun basin is with 20.5-26.5%, which are located in the southeast of the study area, all of them are mesoporosity. And three secondary tectonic units in Yitong graben which is located in the southeast of the study area: Luxiang fault depression and Chaluhe depression, Moliqing depression. The average porosity is 11.2-14.8%, 12.09-13.8%, 4.3-15.49%. Clastic rock reservoir porosity is mainly low porosity, part of the formation appears super-low permeability. Average permeability distribution in $(0.5-75.6) \times 10^{-3}\mu\text{m}$, $(0.539-55.31) \times 10^{-3}\mu\text{m}$, $(0.04-45.79) \times 10^{-3}\mu\text{m}$, mainly for medium-low permeability to ultra-low and super-low permeability. On the whole, the average porosity show us the decreasing trend in the study area from northeast to southwest. It range from high porosity to mesoporosity, and to low porosity, even in ultra-low porosity. the average permeability also show us the decreasing trend from north to southeast and southwest in the study area. It range from medium permeability to medium-low permeability, and to low permeability, even in ultra-low permeability and super-low permeability (Fig.6).

Table. 5 Type of clastic reservoir porosity and permeability

Porosity Types	Porosity ϕ , %	Permeability Type	Permeability K, mD
Super-high porosity	$\phi \geq 30$	Super-high permeability	$K \geq 2000$
High porosity	$25 \leq \phi < 30$	High permeability	$500 \leq K < 2000$
Mesoporosity	$15 \leq \phi < 25$	Medium permeability	$50 \leq K < 500$
Low porosity	$10 \leq \phi < 15$	Low permeability	$10 \leq K < 50$
Ultra-low porosity	$5 \leq \phi < 10$	Ultra-low permeability	$1 \leq K < 10$
Super-low porosity	$\phi < 5$	Super-low permeability	$K < 1$

4. Conclusion

Eastern Songliao basin peripheral group affected by the faulting effect, small and medium-sized basin is formed in the Mesozoic and Cenozoic, mainly developed fan delta facies, lacustrine facies and alluvial fan facies.

1. The study area from northeast to southwest, feldspar content increased, lithic content decreases. In the northeast region of the basin group of paleogene reservoir are mainly lithic arkose, the southwest area of the basin in the reservoir is mainly feldspar sandstone, lithic feldspar sandstone.

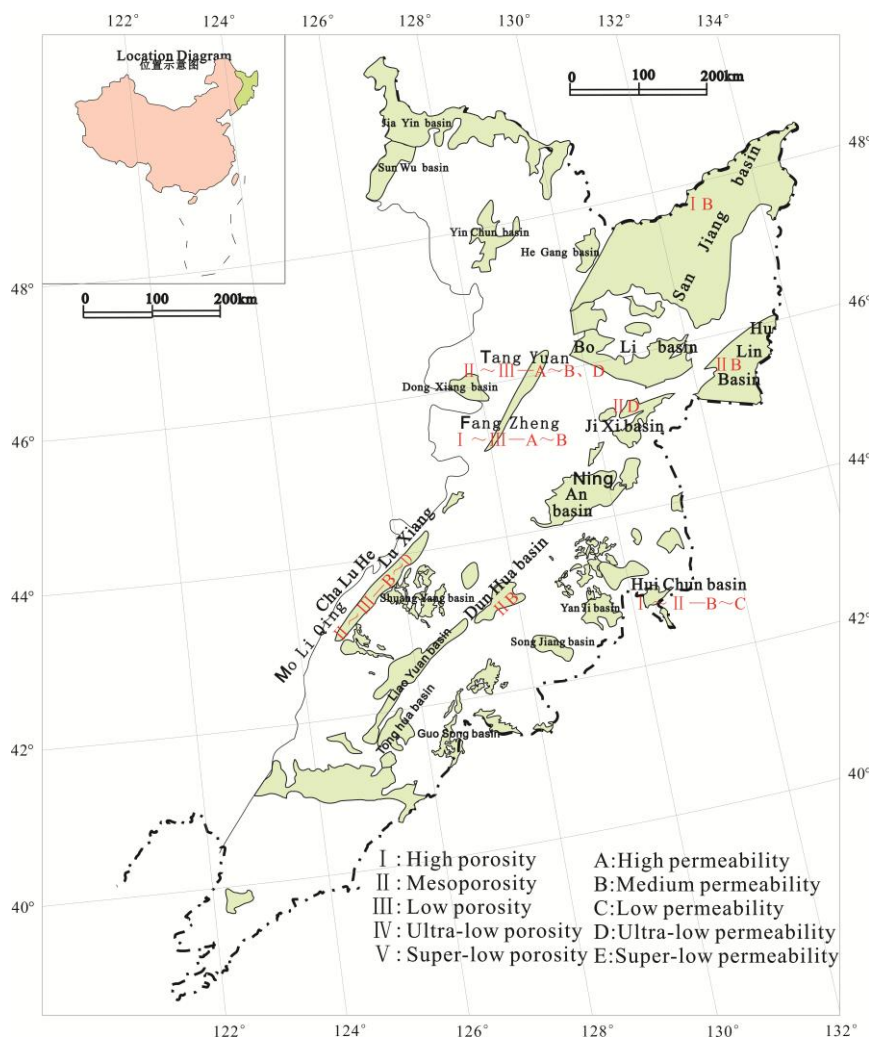


Fig. 6 Paleogene Reservoir porosity and permeability distribution

2. The study area distributed Paleogene clastic basin sorting moderate mainly rounded sphaerocity angular-based particle size from north to south, there are relatively decreasing trend. Clastic structure changed for the better sorting, roundness increased maturity of clastic rocks rising trend.
3. The interstitial material is given priority to with argillaceous, content is large difference. The northern region content is relatively high, regional content is relatively low in the south.
4. In the research area,the overall performance from northeast to southwest with an average porosity decreases, the change from high porosity to mesoporosity and low porosity,even ultra-low porosity.
5. In the research area,the average permeability shows the reduce trend from north to southeast and southwest, the change from high and medium permeability to low permeability,even ultra-low permeability and super-low permeability.

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