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Shale Types and Reservoir Characteristics of China

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In China, Shale gas has just been prospects for the oil and gas exploration and development. At present, the research of shale gas is mainly concentrated on the forming of organic-rich shale and the characteristics of reservoir rock. It has been proved that organic-rich shale developed in more than 10 geological periods around China, by the research on outcrops, shallow survey wells, cores observation and old data review, and by the lab analysis of Ar ions milling and high-distinguishability field launch SEM experimental analysis on shale samples. The rock types, distribution and reservoir characters of organic-rich shale are different from one another.

Three different types of organic-rich shale, including marine facies, marine-terrigenous alternated facies and lacustrine facies shale distributed onshore China according to the depositional environment (see the table and figure). Because of the complicated geologic backgrounds and multistage tectonic evolution, continental sedimentary basins are various and complicated in China. The different evolution processes control the development and distribution of organic-rich shale. 7 sets Palaeozoic marine shales in Yangtze, Tarim and North China platform formed in cratonic area, with the Lower Cambrian Qiongzhusi formation shale and the Upper Ordovician Wufeng formation-the Lower Silurian Longmaxi formation shale in Yangtze areas as two typical examples, which developed with extensive distribution and large thickness. The average thickness of Qiongzhusi formation shale reaches 100 m, and Wufeng formation-Longmaxi formation shale reaches 120 m. The average TOC is 1.0%-1.5%, the organic matter type is mainly I-II₁, and the thermal maturity is 1.6%-4.5%. The characteristics of reservoir are similar with the gas producing shale in North America. The brittle minerals are mainly Quartz, carbonatite and feldspar, the quartz and carbonatite content is 40.1% ~ 65.9%, the clay content is 21.1%-56.4%, and no montmorillonite, without water sensitivity. Shale reservoir is characterized by different types of micro-pores and nano-scale pore space, and the nano-scale micro-pores formed after the organic matter was mature can be the major pore space. Through the analysis of the shale in Wei-201 well and Ning-201 well, it is found that the porosity is more than 4.0%, the permeability is 0.00025md-1.73md, the pore radius is 19-28nm, the rock Yang's modulus exceeds 3.0 mmpa, and the Poisson's ratio is 0.12-0.29. The wells had a lot of gas shows generally in the shale intervals during the drilling and the measured gas concentration is 2.29 - 5.01m³/t. The higher TOC and the higher gas concentration would be.

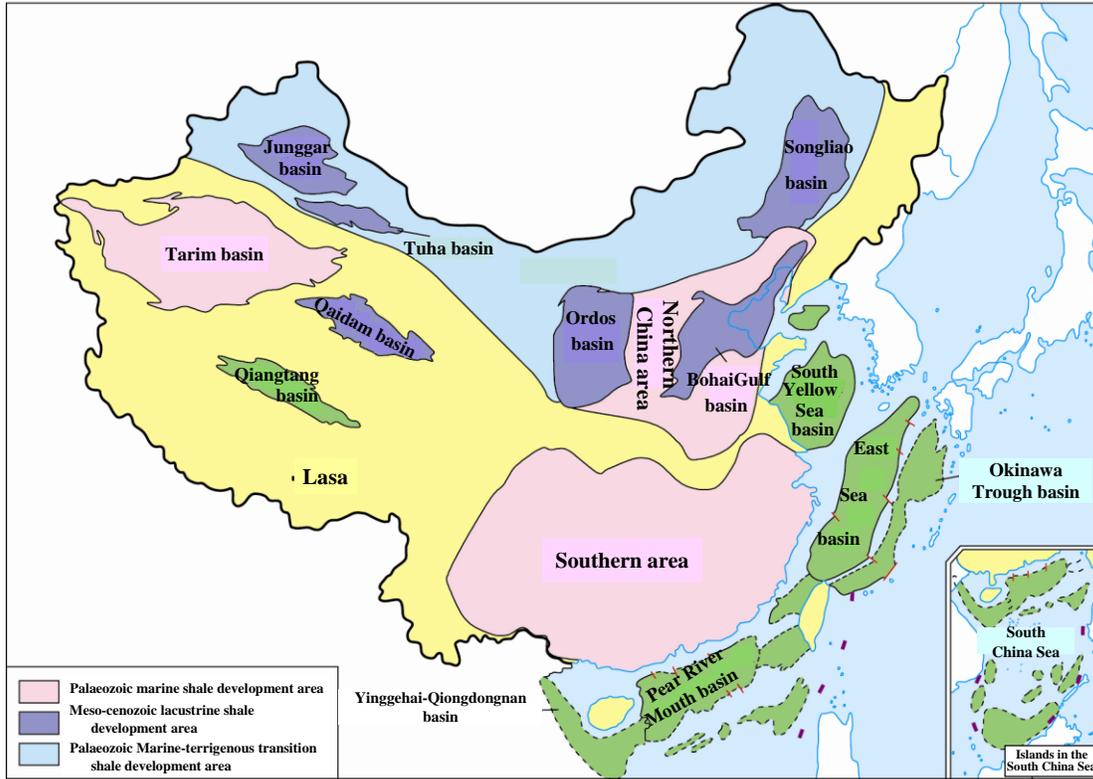
The marine-terrigenous alternated facies shale is distributed at North China, Southern China, Ordos basin and Junggar basin etc.. The TOC value is generally 0.9% ~ 37.98%, and the organic matter type is mainly II-III, and the thermal maturity is 1.1%-2.5%. The brittle mineral is mainly Quartz, and its content is 32% ~ 54%, clay content is 40%-60%, montmorillonite and kaoline developed in partical area, with water sensitivity. There is a lot of gas production generally in the shale intervals during the drilling.

The lacustrine facies shale is distributed widely, with Cretaceous shale in Songliao basin and Triassic shale in Ordos basin as two typical examples. The organic carbon content is 0.5% ~ 22%, and the organic matter type is mainly I-II₁, and the thermal maturity is 0.60%-1.20%. The brittle mineral is mainly Quartz, and the clay content is more than 40%, contains montmorillonite generally, with water sensitivity. There are a lot of gas and oil production in the shale intervals during the drilling and major is wet gas, with overpressure feature generally.

According to the characteristics of development, distribution and reservoir rock of the three organic-rich shale types, combined with the prospect evaluation of the shale gas resources, it is predicted that marine shale is the best, secondly is the marine-terrigenous alternated facies shale and lacustrine shale is the worst. The geothermal evolution process of the lacustrine shale gas is generally too short and most shale is still in the oil generation window. Some shale rock is low hardness and high water sensitivity. Lacustrine shale gas needs more advanced technology for development.

The organic-rich shale types and distribution in China

Shale type	strata	Shale Formation	Thickness/m	Area/10 ⁴ km ²	Distribution area
Marine shale	C	Dewu	50~150m	>6.0	Yunnan、Guizhou and Guangxi
	D	Luofu	100~600m,	13	Yunnan、Guizhou and Guangxi, west and south Hunan
	S	Wufeng-Longmaxi	20~700m	42	Yangtze
	O	Dachengsi	20~100m	3	West of Upper Yangtze
	Є	Qiongzhusi	50~700m,	37~57	Yangtze、Tarim basin
Marine-terrigenous alternated shale	C-P	Longtan	100~350	34~40	Yangtze
			600~1200	8~12	North China
		Dishuiquan-Wuerhe	150~1 000	4.0~6.4	Junggar basin
		Shanxi-Taiyuan	40-100	5.3~7.0	Ordos basin
Lacustrine shale	K	Qingshankou	100~400	4.0~5.0	Songliao basin
	J	Shuixigou	600~1200	2.30~3.5	Junggar and Tuha basin
	T	Yanchang-Xujiahe	150~1000	4.0~5.0	Ordos and Sichuan basin
	E	Shahejie	220-2500	3.0~4.0	Bohai Gulf basin
	R	Ganchaigou	800	0.3~0.5	Qaidam basin



Distribution of three major shale types in China