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Implication of Sedimentary Facies and Shale Gas Accumulation in the Lower Silurian Longmaxi Formation, Eastern Sichuan Basin, China

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1 Introduction

The Lower Silurian Longmaxi Formation is the most prolific shale gas producing unit in the Sichuan Basin by the large thickness and rich resources, which also indicate a bright exploration prospect for the unconventional shale gas. Eastern Sichuan region, the relatively active high and steep structural belt between the stable massifs in Sichuan basin (Fig.1), is influenced by the factors of deep-buried, intense tectonic reworking and fault development. Previous research is mainly based on tectonic structures but ignored the relationship between sedimentary facieses and organic-rich shale accumulation.

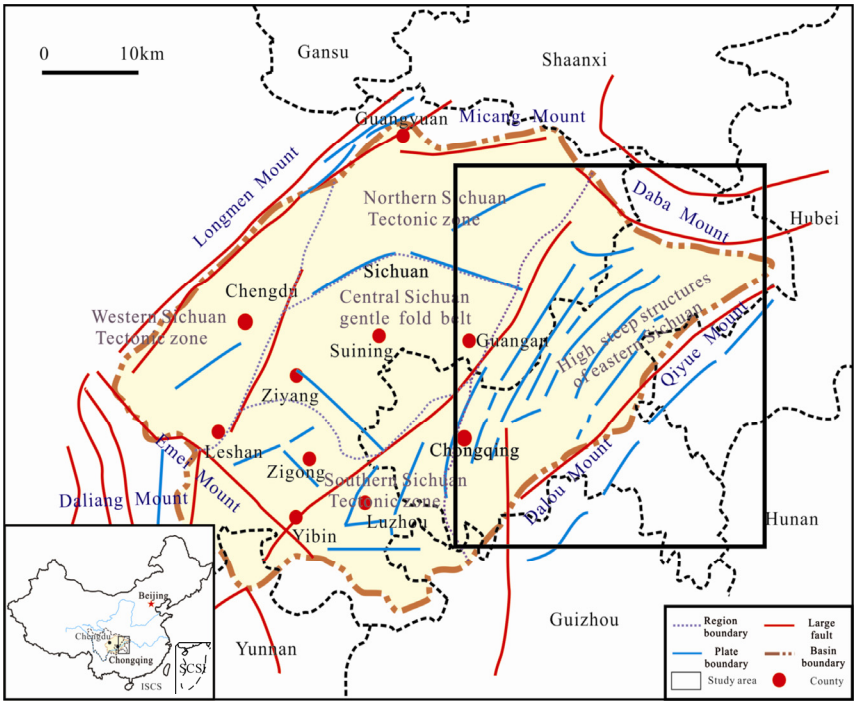

Fig. 1. structural location of the study area.

2 Sedimentary Facies

By the integrated analysis of colour, mineral composition, texture, structure, and biological characteristics of rock in study area of Longmaxi Formation (Fig. 2), rocks are classified as siltstone, mud (shale), siliceous shale, carbonate and contourite. Combining with the characteristics of the colour, sedimentary structure, palaeontology, and well log, 9 lithofacies are identified in the study area: dark grey lamellar silty mudstone, dark grey massive silty mudstone, grey-dark (lime green) lamellar mudstone, grey-dark (lime green) massive mudstone, fossil-bearing mudstone, black graptolite mudstone, grey massive argillaceous siltstone, grey lamellar argillaceous siltstone, and grey contourite. The first 6 lithofacies are organic-rich, which are the most conducive to the accumulation of shale, and they mainly distributed in 30-120 m interval near the bottom of lower Longmaxi Formation.

According to the macro-analysis, micro-scope, and special-analysis derived from the core- drilling, and combining with the regional geological data, the study results show that 2 subfacies with 6 microfacies are recognized in the study area of Longmaxi Formation, including Calcareous Silty Shelf, Muddy Silty Shelf, Muddy Limy Shelf in the Inner Shelf, and Silty Muddy Shelf, Muddy Shelf, Contour Current in the Outer Shelf (Fig. 3). The organic-rich shale belongs to the Outer Shelf environment, vertically distributed in bottom of Longmaxi

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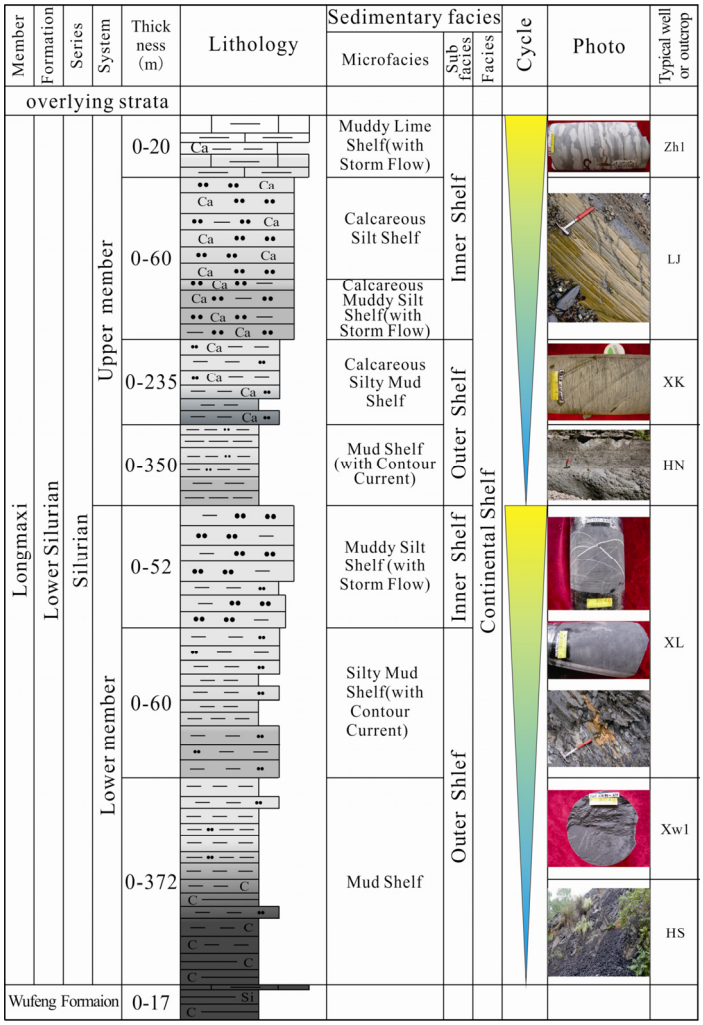

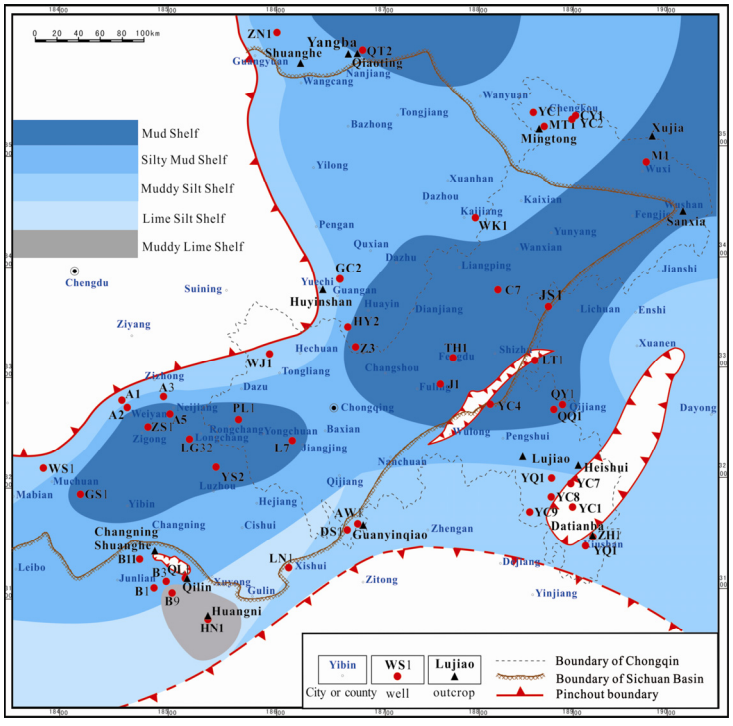

Formation upper and lower intervals in the whole study area, and laterally distributed near Longchang-Yongchuan, in the southeast of Lingshui-Wuxi, and in the north of Changshou-Qianjiang. The Outer Shelf is the most conducive to the shale gas generation and accumulation.

3 Characters and Distribution of High-quality Shale

Results of organic geochemistry and reservoir characters of Longmaxi Formation indicate that the deposit formed in a deep-water and low-energy reducing environment, which beneath the normal wave base, and developed a large number of zooplankton and Phytoplankton. The long-term reducing environment made the abundant organic matter deposit and conserve largely.

In addition, the high-quality shale reservoirs are characterized by the data of abundant organic matter (the average of TOC to 2.12%), the high maturity (the average of *R*o 2.35%), various of reservoir space, thick strata (17-146m), and the type of organic matter (I type) of the black shale suggest that it is conducive to formation of shale reservoir in the bottom of lower interval of Longmaxi Formation (Fig. 4). Moreover, there are more brittle mineral than other formations in the study area, the content is generally greater than 40%. Under the condition of tectonic stress, emerging micro-pore and micro-crack in shale strata, to provide good conditions for the saving of shale gas; the high content brittle mineral also provides favorable conditions of shale gas fracturing.

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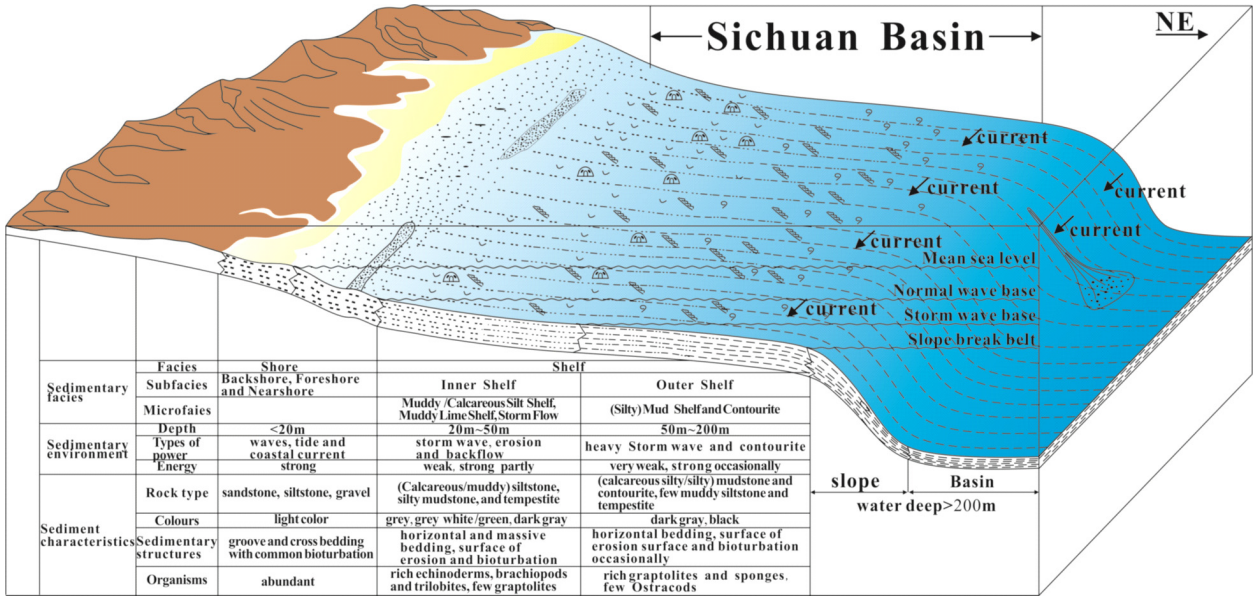
Fig. 2. Collective Diagram. Upper part is generalized geological section of strata and sedimentary facies, and the lower part is the planform distribution map of sedimentary facies in Lower Silurian Longmaxi Formation.



		Shore	Shelf	
Sedimentary facies	Facies			
	Subfacies	Backshore, Foreshore and Nearshore	Inner Shelf	Outer Shelf
	Microfaies		Muddy /Calcareous Silt Shelf, Muddy Lime Shelf, Storm Flow	(Silty) Mud Shelf and Contourite
Sedimentary environment	Depth	<20m	20m~50m	50m~200m
	Types of power	waves, tide and coastal current	storm wave, erosion and backflow	heavy Storm wave and contourite
	Energy	strong	weak, strong partly	very weak, strong occasionally
Sediment characteristics	Rock type	sandstone, siltstone, gravel	(Calcareous/muddy) siltstone, silty mudstone, and tempestite	(calcareous silty/silty) mudstone and contourite, few muddy siltstone and tempestite
	Colours	light color	grey, grey white /green, dark gray	dark gray, black
	Sedimentary structures	groove and cross bedding with common bioturbation	horizontal and massive bedding, surface of erosion and bioturbation	horizontal bedding, surface of erosion surface and bioturbation occasionally
	Organisms	abundant	rich echinoderms, brachiopods and trilobites, few graptolites	rich graptolites and sponges, few Ostracods

Fig. 3. Sedimentary model of Longmaxi Formation in eastern Sichuan Basin.

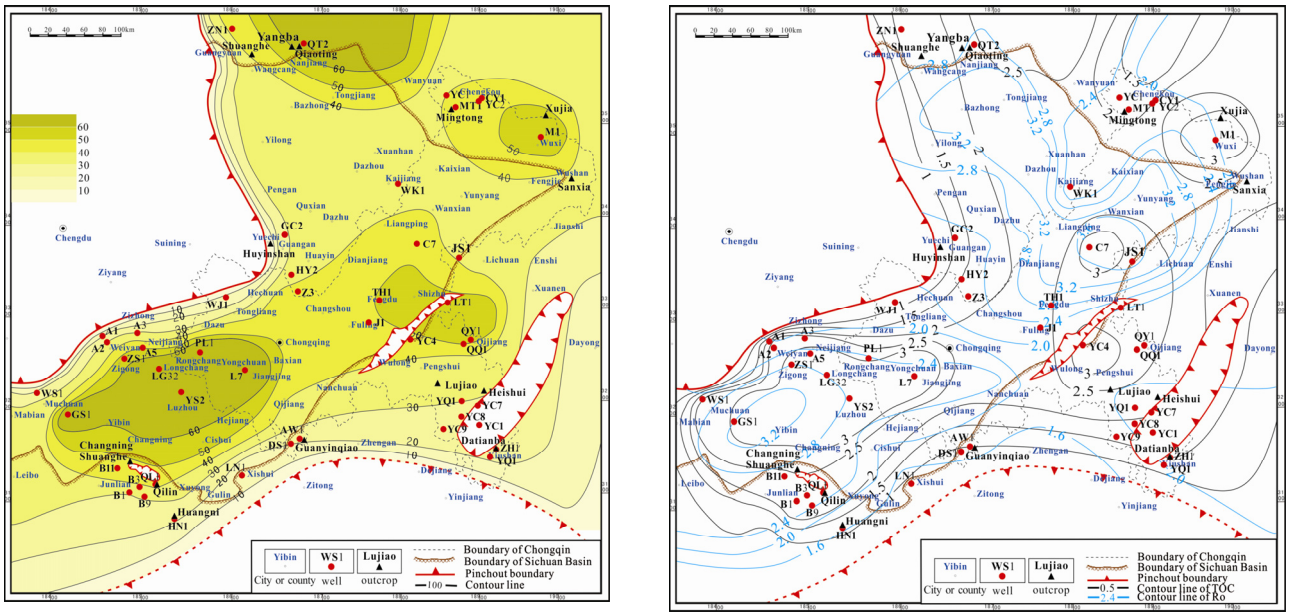


Fig. 4. Thickness contour map of organic-rich shale (Left) and Congruency map of TOC and *R*o (Right) in Lower Silurian Longmaxi Formation, eastern Sichuan Basin.

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