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Review

Diagenetic alterations and porosity evolution of oilsand reservoir in shaximiao formation, Houba area, Northwestern basin Sichuan

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Abstract

Oilsand in China is very rich, especially in northwestern Sichuan basin. Houba oilsand is one of the famous oilsand belts, it consists of medium-coarse grained sandstone with high porosity and permeability. The genesis of those pores is very important in the research of Houba oilsand reservoir. Based on thin section analyses, SEM observation and X-ray diffraction (XRD) analysis, the diagenesis and pore evolution of oilsand reservoir have been studied. It shows oilsand reservoir in Shaximiao Formation had experienced the early diagenesis and the late diagenesis including early mechanical compaction, four times cementation and two times dissolution. Diagenetic alterations affect the pore evolution in the long geology history. At last, porosity evolution model of the oilsand reservoir have been established.

Keywords: Oilsand reservoir; Diagenetic alterations; Porosity evolution; Houba area, Northwestern Sichuan basin

INTRODUCTION

As a unconventional resource with great potential, Oilsand resource is very rich in the world, especially in Western Canada with geological reserve of 0.177×10^{12}t (Wightman, 2003; Higley et al., 2009). In China, it is also very rich with a preliminary investigated geological reserve of nearly 5.97×10^{9} t (Liu et al., 2008), Songliao basin, Junggar basin and Sichuan basin are enriched in oilsands. Surrounded by Northwestern edge of Sichuan basin and the frontal zone of Longmenshan Mountain fault fold belt (Fig. 1a), Houba oilsand has been researched for long time, with good hydrocarbon showing, widely distribution of crop oil seepage and abundant reserves of 0.473×10^{8}t. Houba oilsand crops out along the Frontier Longmenshan Mountain with good hydrocarbon shows (Fig. 1b). Oilsand developed in the Middle Jurassic ShaximiaoFormation, it consists mostly of medium-coarse grained sublitharenite, subarkose and lithic arenite which deposited in distributary channel environment of the delta plain based on the observation of cores and thin sections (Table 1). The average porosity of the oilsand reservoir is 16.46% while the average permeability is 44.94mD, which shows the characteristic of high-porosity and high-permeability. Oilsand diagenesis and porosity evolution has not yet been studied, but it is very important to the further research of oilsand reservoir.

MATERIALS AND METHODS

About 109 samples from 4 wells and 2 field outcrops have been analyzed including thin section analyses, SEM observation and X-ray diffraction (XRD) analysis. Combined with physical analysis, relationship between diagenetic alterations and porosity evolution of the Houba oilsand in shaximiao formation has been discussed.

Diagenetic alterations

Oilsand reservoir in Shaximiao Formation had expe-

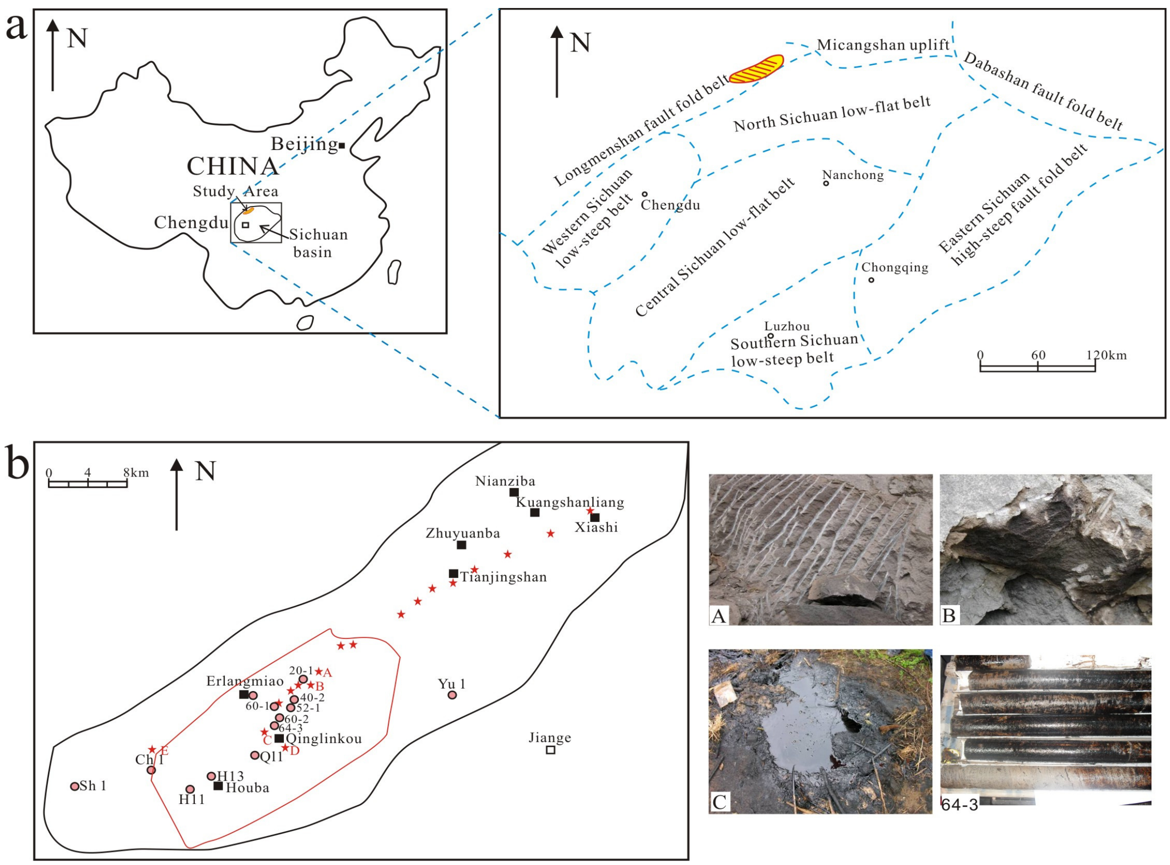

Figure1. Tectonic map of Houba oilsand and its outcrop along the Longmenshan Mountain

rienced the early diagenesis and the late diagenesis including early mechanical compaction, four times cementation and two times dissolution.

Compaction

The compaction of oilsand reservoir is mechanical compaction which caused a large number of primary pores disappeared. Under the microscope, ductile grains were weakly or strongly deformed with line contacts, Concave-convex contacts, grain breakage and glimmer deformation (Fig. 2a).

Cementation

The cementation of oilsand reservoir in the study area includes the early ferruginous and chlorite cementation, the late kaolinite and calcite cementation (Table 1). The four times cementation occupied most of primary pore spaces. Early ferruginous cements precipitated from the formation saturated with Fe^{2+}, and it grew around the grains boundary (Fig. 2b).Chlorite cementation is the widely distributed cementation, it developed as the chlorite coating around the grain surface after ferruginous coatings(Fig. 2c). Mechanical strength which was increased by the continuing growth of chlorite coatings could resist part of mechanical compression from overlying formation during the burial process. It plays an active role in preserving pore space (Aagaard et al., 2000; Anjos et al., 2003; Berger et al., 2009). Authigenic kaolinite cements filled in the early dissolution pores as well developed euhedral pseudohexagonal plates forming booklets and aggregates and as thin, skeletal subhedral plates commonly forming vermicules (Fig. 2d). Calcite cements filled in the residual pores and cleavage cracks of feldspars with the acid condition of formation water changed to alkaline condition (Fig. 2e).

Dissolution

The early dissolution occurred in the late Jurassic, the partial area along the Longmenshan fault fold belt into the hypergene period. Affected by the surface water contain CO_2, dissolution often occurred in some nonresistance

Table 1. The component of Shaximiao oilsand and its main cementations

Samples	Lithology	Thicknes (m)	Sand component (%)			Cementation component (%)			
			Quartz	Feldspar	Rock fragment	Ferruginos	Chlore	Kaoline	Calcite
Sh1	Subarkose	8	30~40	35	3~6	1	3~12	/	0~8
64-3	Subarkose	56	55~60	15~20	12	1~2	10	5	2
Section A	Sublitharenite	2	48	22	16	2	2	2	/
Xiashi	Sublitharenite	30	59	11	20	2	4	3	4
Section D	Subarkose	25	40	15	25	1	4	1	2

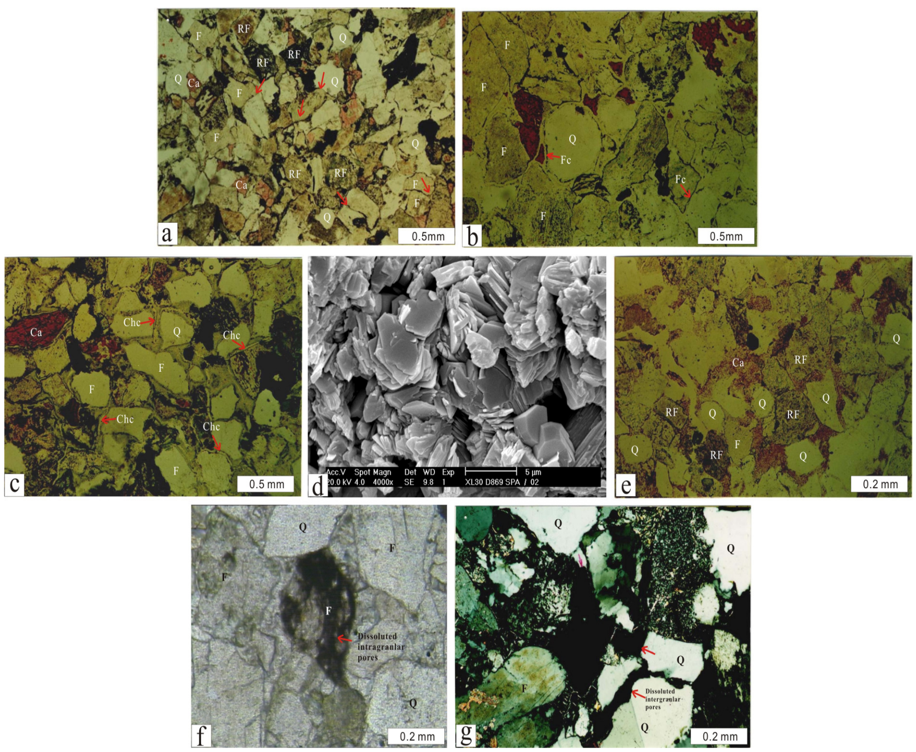

Figure 2 Diagenesis characteristics of Shaximiao oilsand reservoir in Houba area

A: subarkose with concave-convex contacts, Sh1 well; b:the early ferruginous cementation around the grain surface; c: the chlorite coating cementation; d: Authigenic kaolinite filling in the pores; e:calcite cements; f:the early dissolved intragranular pores; g:dissolved intergranular pores. (Ca: calcite; Q:quartz; F: feldspar; RF: rock fragments; Chc: chlorite coating; Fc: ferruginous coating)

grains (feldspar, lithic) or along fractures (Fig. 2f). A lot of dissolved intergranular pores and intragranular pores with irregular embayed boundary generated and most of they can act as reservoir spaces. The late dissolution occurred in the Paleogene time, deep liquid hydrocarbon migrated into the residual pores of Shaximiao Formation sandstone. Enlarged dissolution occurred in those sandstones (Fig. 2g).

Porosity evolution of reservoir

Through the research of diagenesis and its effect on reservoir pores, Porosity evolution model of oilsand reservoir in Shaximiao Formation has been established

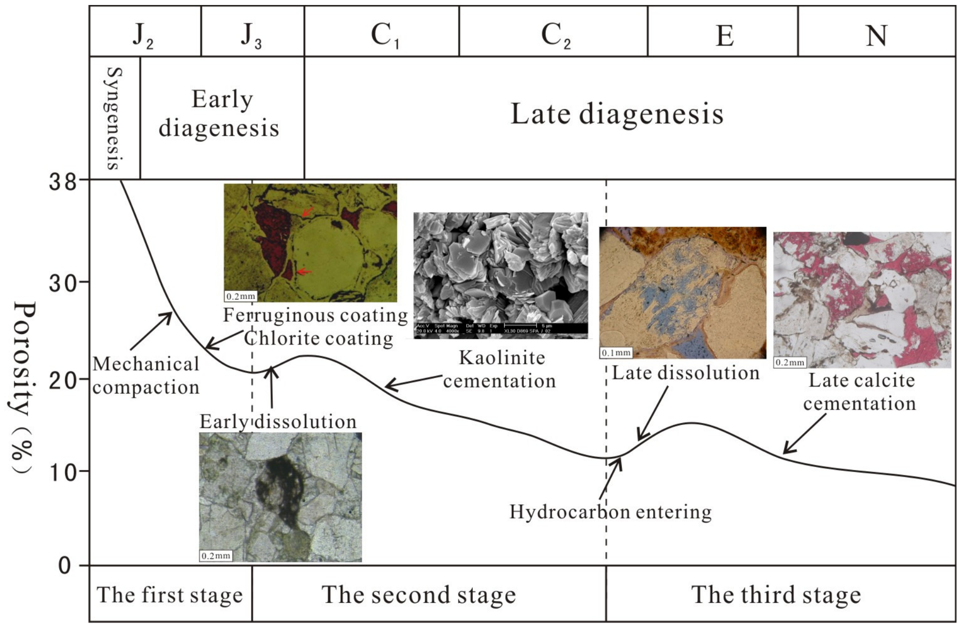

Figure3. Porosity evolution model of oilsand reservoir in Shaximiao Formation

which can be divided into three stages according to its porosity change (Figure 3):

The first stage

The stage started in the sediment buried and basically completed prior to the late Jurassic dissolution. Compaction and cementation of ferruginous and clay occurred in this stage. Many primary pores had lost after compaction and cementation. The residual primary porosity is about 20%.

The second stage

The Yanshanian Movement in the late Jurassic made the partial area along the Longmenshan fault fold belt into the hypergene period. Affected by the surface water contain CO_2, some freely soluble minerals in the strata such as feldspars and aluminum silicate minerals dissolved and made the porosity increased. At the same time, a large number of Ca^{2+}, Mg^{2+} and K^+ decomposed from these freely soluble minerals transferred, then kaolinite cementation and a small amount of quartz overgrowths occurred, the process led the primary pore to be completely filled. It still had the primary residual pores about 10%.

The third stage

This stage is in the Himalayan tectonic active period of Paleogene. The deep liquid hydrocarbon flowed upwards into the Shaximiao Formation porous sandstones through fractures, which formed the current oil-bearing sandstone (Tong, 1992). In this period, due to the influence of organic acid water, the intergranular dissolved pores and the intragranular dissolved pores formed in some soluble minerals and they had a good reservoir condition, now they are the excellent pore types in oilsand reservoir. During the late dissolution process, more Ca^{2+} decomposed from the soluble minerals caused the late calcite cementation.

CONCLUSION

(1) Houba Shaximiao oilsand is in the northwestern Sichuan basin, its reserve is very large and its reservoir is medium- coarse grained sandstones. Diagenetic alterations of Shaximiao Formation oilsand play an important role in its reservoir evolution.
(2) Oilsand reservoir in Shaximiao Formation had experienced the early diagenesis and the late diagenesis including early mechanical compaction, four times cementation and two times dissolution.
(3) Porosity evolution model of oilsand reservoir in Shaximiao Formation can be established. It includes three stages.

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