

The genetic type of Mixed Sedimentation in Permian Lucaogou Formation, Jimsar sag

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Abstract: Mixed sedimentation of terrigenous clastic and carbonate is a sedimentary phenomena which has special sedimentational mechanism and significance. Although many progresses have been achieved in the research of mixed sedimentation of terrigenous clastic and carbonate, much divergence still exists in the geological concepts, classification, mechanism of hybrid processes and the controlling factors. Based on outcrop surveying and borehole core observation as well as thin section and SEM (scanning electron microscopy) analyses, we propose in the paper that the Lucaogou Formation is a typical saline lacustrine depositional sequence of mixed siliciclastic and carbonate sediments in Jimsar sag, which contains two levels of implication. There are three genetic types of mixed Sedimentation in this area include source mixing, in-situ mixing and edge facies mixing. This paper analyses the mixed deposits of study are carefully, such as geological setting, petrological characteristic and depositional environment, etc, discusses controlling factor of the mixed deposits.

Keywords: Jimsar sag; saline lacustrine deposition; mixed sedimentation types; controlling factors

I. Introduction

In the early 1950's, the phenomenon of mixed sedimentation of terrigenous clastic and carbonate has been realized. The research of mixed sedimentation can date from early 1970's, which click into plgenius until the concept of mixed sedimentation was put forward by Mount in 1984^[1]. In 2011, Chinese scholar Feng Jinlai illuminated that the mixed sediments can form favourable reservoir^[2]. The research results from Chinese scholar Ding Yi shows that the mixed sediments formed in lacustrine facies has a close relationship with tight oil in continental facies. The international and domestic scholars have culminated in consensus on the viewpoint that the research of mixed sedimentation has important significance to the development of unconventional oil and gas.

II. Research Situation In Research Area

The tight oil in Jimsar sag of Junggar Basin has become the key blocks of tight oil exploration and development, this block got an important breakthrough in exploration work in recent years^[4]. Combined the core observation and thin section analysis, typical saline lacustrine mixed sedimentation are developed widely in Permian Lucaogou Formation. The research of Lucaogou Formation were mainly focus on the lithology and sedimentary environments^[5,6], all the results shows that the lithology in Lucaogou Formation were mainly consisted of rhythmically interbedded dolomite/siltstone and mudstone. Based on the study of typical well, stratigraphic sequence classification was put forward which indicate that the whole formation belongs to a whole third order sequence, and sequence stratigraphic frame of Lucaogou Formation was established at the same time. The plane distribution rule of sedimentation of each tract made clear that the sedimentary environment belongs to saline lacustrine facies^[7]. It is indicated that sedimentation studying can be reached through well-logging lithology analysis, and the lithology types are divided into three types as a whole include mudstone, carbonate and silty sand stone^[8]. There are two sweet points in Lucaogou Formation, while the sedimentation of lower sweet point belongs to delta-front subfacies and shallow lake subfacies, but the sedimentation of upper sweet point is consist of carbonate sedimentary. All the research results indicate that Lucaogou Formation not only contain clastic rocks but also carbonate. But the detrital rocks and carbonate are studied independently, therefore the mixed sedimentation are ignored.

III. Basic Research

The Jimsar sag located off the southeast of the Junggar basin, the area of its structural is 1287km². The Permian Formation in the Jimsar sag can be divided into four formation segments from down to up, include Wulabo Formation, Jingjingzi Formation, Lucaogou Formation and Hongyanchi Formation, and the Lucaogou Formation is the major target of tight oil. The Lucaogou Formation can be divided into upper segment (P₂l₂) and lower segment (P₂l₁). The two segments in Lucaogou Formation also can be divided into two sand groups, the sand group of P₂l₂² and P₂l₁² are the major development formation of tight oil. The upper sweet point

develops in P₂l₂ and the lower sweet point comes within P₂l₁ [8].

From the land to offshore, from the shallow to the deep water, mixed sedimentation in lacustrine facies which consist of carbonate rocks and terrigenous detrital rocks is a very common phenomenon, whether the mixed sedimentation are modern sedimentation or ancient sedimentation. Many factors can play an important role in the progress of mixed sedimentation, so the research of mixed sedimentation is much more difficult than single sedimentary system such as carbonate sedimentary system and terrigenous detrital sedimentary system [9].

1. Lithological features

It is characterized by complicated mineral compositions and ore fabrics in The Permian Lucaogou Formation, include quartz, potassium feldspar, anorthose, calcite, dolomite, hematite, analcite, clay and so on. The feldspar has the highest percentage and the clay has the lowest percentage, while the percentage of quartz is equal to dolomite. It shows that the rock types of tight oil reservoirs are dominated by carbonate rocks and terrigenous detrital rocks, while certain segments contain a small number of pyroclastic rocks and normal mixed sedimentary rocks.

In different layer, the relative amount of terrigenous detrital can range from 0 to 100%, and its average content is 52.8%. In the mineral compositions, terrigenous detrital components shows the characteristics that clastic particles are consist of feldspar, low compositional maturity and low quartz content. And the reservoir space are mainly dissolution pores and bits of residual original intergranular pore.

Compared with terrigenous detrital components, the carbonate components' average content is 37.7%. In small part, the content of carbonate components can reach 90%, which constituted the main rock component types. Through mineral constituent analysis, the carbonate components is mainly Micritic dolomite. The reservoir space is low-development in pure dolomitic.

The pyroclastic components shows its own characteristics, include finer particle, larger difference of relative content distribution. Compared with the former components, the main distribution range is between 0 and 30%, while has the largest discrepancy between different range.

2. Characteristics of mixed sedimentation

Based on the research before, the mixed sedimentation can be divided into three types include source mixing, in-situ mixing and edge facies mixing.

(1) In-situ mixing

At shore-shallow lake zone, saline lake will become the source of carbonate sediment, and the limestone can deposit in these areas. Under the condition of terrigenous sediment source material supply is sufficient, the mixed sedimentation between beach and bar and limestone. When the lake level become lower and lower, the large areas of exposed evaporation will happen in shore-shallow lake. At the same time, the strength of capillary condensation becomes more and more obvious, and a large area of mixed sedimentation between dolomite and terrigenous detrital will form in shore-shallow lake. Under the condition of no terrigenous material supply, only mixed sedimentation between limestone and dolomite can be seen.

Positive rhythm can be found in vertical profile of in-situ mixing. Through core observation, it is indicated that gradually varied contact relation and abrupt contact relation can be found among dolomitic, silt dolomite and siltstone. And in general, abrupt contact with mudstone and limestone will occur at top and base. Terrigenous sediment source and lake level fluctuations are the key controlling factors of in-situ mixing, and this kind of mixed sedimentation is common in P₂l₂ [2].

(2) Edge facies mixing

The concept of edge facies mixing is a kind of mixed sedimentation which formed in the transition zone among different sedimentary facies. The component of mixed sedimentation are controlled by advantageous sedimentary facies. For example, when the mixing zone is closed to sandy beach and bar, the sedimentary characteristics of edge facies mixing looks more like sandy beach and bar. When the mixing zone is closed to dolomitic flat which formed in exposed evaporation environment, the sedimentary characteristics looks more like dolomitic flat. At the environment of shore-shallow lake, sandy dolomitic flat and pelitic dolomitic flat are the product of edge facies mixing between dolomitic flat microfacies and terrigenous microfacies.

The types of mixed sedimentation can be predicted by their own distributive location. Usually, the edge facies mixing distributed in the environment among dolomitic flat and sandy beach and bar, while the pelitic dolomitic flat located in the edge of sandy beach and bar which usually belongs to the transition zone between shallow lake mudstone and dolomitic flat. In the transition zone between sandy beach and dolomitic flat, the sandy dolomitic flat is frequently occurring. The changes from dolomitic flat to sandy beach and bar, from pelitic dolomitic flat to shallow lake mudstone, the water depth got deeper and deeper, and the water energy reduced in turn. In the process of this change, terrigenous component in mixed stone continues to decline, while

the clay content increased continuously. This kind of mixed sedimentation is common in P_{21}^2 and P_{22}^2 .

(3) Source mixing

Due to the volcanism in Permian, it is resulted that pyroclastic components widespread in the Lucaogou Formation^[10]. Higher tuffaceous component in P_{21}^2 shows that P_{21}^2 sedimentation period has a number of violent volcanic activity. The pyroclastic components deposited in the whole lake through eolian transport. Therefore, the volcano can be treated as a source.

The alkaline ash with tuffaceous component was provided by volcano source. During the process of sedimentation which have three sources include terrigenous sediment source, carbonate source and volcano source, the source mixing will appear. Tuffite, dolomitic siltstone and dolomiticrite has a gradually varied contact relation in the vertical. Source mixing is distributed mainly in the transition area between dolomitic flat and delta in the plane.

3. Controlling factor of mixed sedimentation

The controlling factors of mixed sedimentation of the tight oil reservoir in Lucaogou formation of Jimsar sag are complex and diverse, and majority of them are interact and function together. The characteristics of mixed sedimentation system were greatly controlled by climate and structure. Also the mixed sedimentation is the result of comprehensive function of multiple factors include terrigenous supply rate and carbonate productivity which controlled by the sea level.

In the sedimentation period of Permian Lucaogou Formation, the controlling effect of tectonism was not obvious, while the controlling factors has three aspects include lake level fluctuation、climate and hydrodynamic condition. Under the circumstance of lake level rising, terrigenous material supply was restrained, the distribution zone of sandy beach and bar and delta narrowed down quickly, and the distribution range of exposed evaporation reduced at the same time. The strength of exposed evaporation was controlled by the climate obviously, which controlled the capillary dolomitization indirectly. The re-transportation of terrigenous materials controlled by hydrodynamic condition will deposit again along the lakeshore. It is indicated that the hydrodynamic condition is one of the controlling factors which controlled the source mixing and in-situ mixing of sandy beach and bar and dolomitic flat.

IV. Others

In order to be able to carry out the comprehensive geological research of tight oil better, many laboratory, research center and other institutions in China devote themselves to the study of unconventional oil and gas resources. At the same time, China has set up many national level research project such as “973” program and mega project of science research, and these projects will offer a bigger communication platform and a broad space for development for unconventional oil and gas resources.

V. Research Prospects

The Chinese continental tight oil reservoir mainly form from fine-grained sedimentary environment such as delta front-prodelta-semi deep lake, and it has a big different from coarse-grained sedimentary environment which composed of river-alluvial fan-deltaic plain. Therefore, it is important to carry out the research of lithology identification and sedimentation mechanism in continental facies, and study the sedimentation and its progress which based on the fine-grained lithology identification. All the research contents above will make a great contribution to the enrichment region selection and distribution prediction of unconventional oil and gas resource.

VI. Conclusion

1. The tight oil reservoir rocks in Permian Lucaogou Formation of Jimsar sag are characterized by complex mineral compositions and multiple rock components, classified as transitional mixed sedimentary rocks.
2. There are three genetic types of mixed Sedimentation in this area include source mixing, in-situ mixing and edge facies mixing. In-situ mixing and edge facies mixing distributed widely which played an important role in Lucaogou Formation.
3. There are three kinds of mixed Sedimentation controlling factors in Lucaogou Formation
4. include lake level fluctuation、climate and hydrodynamic condition.
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