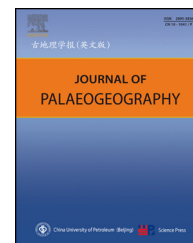


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# Sedimentary facies and lithologic characters as main factors controlling hydrocarbon accumulations and their critical conditions

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## ARTICLE INFO

### Article history:

Received 23 October 2013

Accepted 25 September 2014

Available online 21 September 2015

### Keywords:

Sedimentary facies

Lithologic characters

Hydrocarbon accumulation

Hydrocarbon threshold

Hydrocarbon exploration

## ABSTRACT

Taking more than 1000 clastic hydrocarbon reservoirs of Bohai Bay Basin, Tarim Basin and Junggar Basin, China as examples, the paper has studied the main controlling factors of hydrocarbon reservoirs and their critical conditions to reveal the hydrocarbon distribution and to optimize the search for favorable targets. The results indicated that the various sedimentary facies and lithologic characters control the critical conditions of hydrocarbon accumulations, which shows that hydrocarbon is distributed mainly in sedimentary facies formed under conditions of a long lasting and relatively strong hydrodynamic environment; 95% of the hydrocarbon reservoirs and reserves in the three basins is distributed in siltstones, fine sandstones, conglomerates and pebble-bearing sandstones; moreover, the probability of discovering conventional hydrocarbon reservoirs decreases with the grain size of the clastic rocks. The main reason is that the low relative porosity and permeability of fine-grained reservoirs lead to small differences in capillary force compared with surrounding rocks small and insufficiency of dynamic force for hydrocarbon accumulation; the critical condition for hydrocarbon entering reservoir is that the interfacial potential in the surrounding rock ( $\Phi n$ ) must be more than twice of that in the reservoir ( $\Phi s$ ); the probability of hydrocarbon reservoirs distribution decreases in cases where the hydrodynamic force is too high or too low and when the rocks have too coarse or too fine grains.

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## 1. Introduction

Different sedimentary facies develop in different structural units of basins, different characters of lithologic rocks develop

in different sedimentary facies, and different porosity and permeability develop in different rocks. The mechanism and enrichment of hydrocarbon accumulation in reservoirs with different porosity and permeability vary in petroliferous

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Peer review under responsibility of China University of Petroleum (Beijing).

<http://dx.doi.org/10.1016/j.jop.2014.09.001>

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basins. It is of great significance to study the main factors controlling hydrocarbon accumulations and their critical conditions to reveal the hydrocarbon distribution and to optimize the search for favorable targets.

Based on the study of the hydrocarbon characteristics of more than 1000 clastic hydrocarbon reservoirs of Bohai Bay Basin, Tarim Basin and Junggar Basin, China, it is indicated that the sedimentary facies and lithologic characters are the main controlling factors for hydrocarbon accumulation. Hydrocarbon is distributed mainly in delta sandstone facies formed under conditions of a long lasting and relatively strong hydrodynamic environment; few hydrocarbon reservoirs were discovered in alluvial-fan conglomerates under too strong hydrodynamic conditions, whereas they were not discovered in mudstone facies because they developed under too weak hydrodynamic conditions. Statistical analysis shows that in the three basins, 95% of the hydrocarbon reservoirs and reserves are distributed in siltstones, fine sandstones, lithified gravels and pebble-bearing sandstones, accounting for 27%, 45%, 13% and 10%, respectively; their grain sizes were between 0.1 mm and 0.5 mm, and the probability of conventional hydrocarbon accumulation decreases with the diminishing grain size. Besides, the critical conditions and the probability of hydrocarbons distribution were analyzed. The critical condition for hydrocarbon entering reservoir is that the interfacial potential in the surrounding rock ( $\Phi_n$ ) must be more than twice of that in the reservoir ( $\Phi_s$ ); the probability of hydrocarbon reservoirs distribution decreases in cases where the hydrodynamic force is too high or too low and when the rocks have too coarse or too fine grains.

## 2. Controlling factors of hydrocarbon accumulation

### 2.1. Sedimentary facies

The issue of sedimentary facies controlling hydrocarbon accumulation has been widely discussed (Feng, 1994; Gu and He, 1994; Miall, 1984; Wu and Xue, 1993; Zhao, 2001). Sedimentary facies controlling hydrocarbon accumulation refers to reservoir having high porosity and permeability favorable for hydrocarbon accumulation. The identification of favorable sedimentary facies then guides efforts to identify the distribution of favorable exploration areas in sedimentary basins. Reservoir formed in different sedimentary facies is significantly different in clastic composition, structure, particle size, sorting, and single-layer thickness. Thus, it is clear that their original reservoir conditions were different. The better the original reservoir condition, the more easily was the reservoir changed to form high-porosity and permeability areas. Therefore, favorable sedimentary facies are often associated with high porosity and permeability reservoir (Ma et al., 1999; Yao et al., 2000; Zhang et al., 2004; Zhao et al., 2008). Reservoir with high porosity and permeability is a prime area for hydrocarbon accumulation. Hydrocarbon exploration and experiences show that the palaeo-sedimentary environment controlled the formation and distribution of hydrocarbon reservoirs around the world (Tian and Zhang, 1996). In different sedimentary facies, the accumulation and

preservation conditions were different owing to differences in the sedimentary environment; therefore, the study of hydrocarbon accumulations controlled by sedimentary facies is highly significant for predicting favorable hydrocarbon accumulation areas and improving exploration efficiency.

#### 2.1.1. Bohai Bay Basin

Sedimentary facies types and the characteristics of rift basins control reservoir scales, distribution positions, properties, hydrocarbon reservoirs types, and hydrocarbon accumulation conditions (Wang and Wang, 1997). Clastic sedimentary facies of Dongying Depression of Bohai Bay Basin mainly include alluvial fan, fluvial, fan delta, nearshore subaqueous fan, shore and shallow lake beach, delta, and turbidite fan. The sedimentary facies and hydrocarbon reservoirs distribution are shown in Figs. 1–4. Studies of the relationship between sedimentary facies and reservoirs show that the favorable sedimentary facies for hydrocarbon accumulation are arranged as follows (from poor to favorable): turbidite fan, delta, nearshore subaqueous fan, fluvial, shore and shallow lake beach, and fan delta.

In Neogene of western Liaohe Depression of Bohai Bay Basin, sedimentary facies are mainly fan delta, delta in Paleogene, meandering river, and braided river. Statistical results show that western Liaohe Depression mainly developed six types of sedimentary facies and thirteen types of sedimentary subfacies and that hydrocarbon reservoirs distribution was controlled by sedimentary facies, which was quite evident. At present, most of the discovered hydrocarbon reservoirs are distributed in the fan delta front (Figs. 5 and 6), and the hydrocarbon reservoirs of Neogene are mainly distributed in the river and flood subfacies. The distributary channel sand bodies of the fan delta front has good sorting, high maturity, good porosity, and permeability, and in addition, the horizontal and vertical extent of the sand bodies is large, and can be overlapped, especially at the slope. The fan delta source can cover hundreds of square kilometers and have regional caprocks with Member 3 and Member 1 of the Shahejie Formation, which became the most favorable hydrocarbon accumulation areas.

#### 2.1.2. Tarim Basin

In the Tarim Basin, sedimentary facies mainly are dominated by tidal flat and shore facies. Statistical results clearly show that the hydrocarbon reservoirs distribution was controlled by sedimentary facies (Figs. 7 and 8). At present, most of the discovered hydrocarbon reservoirs are distributed in the foreshore–shoreface, estuary, tidal flat, shelf, and delta facies (Fig. 9). Carboniferous hydrocarbon reservoirs are mainly distributed in the foreshore–shoreface, estuary, and shelf shallow sea (Fig. 7), and Silurian hydrocarbon reservoirs are mainly distributed in the tidal flat and delta facies (Fig. 8).

#### 2.1.3. Junggar Basin

In the Jurassic strata of Junggar Basin, sedimentary facies were mainly developed as river-delta-shore-shallow lacustrine facies, and only locally as alluvial fan and beach-bar facies (Fig. 10). Statistical results show that most of the discovered hydrocarbon reservoirs are distributed in delta facies, and that the delta front was the most favorable facies

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