Sedimentary characteristics and hydrocarbon potentials of longitudinal gravity flow deposits in the east subsag of Saihantala Depression

Guo Yanchen¹, Yu Xuntao¹, Xing Yawen², Feng Heqing²

¹School of Earth Science, Northeast Petroleum University, Daqing Heilongjiang 163318)
²Petrochina huabei oilfield branch, Renqiu, Hebei 062552
³yuxuntao@petrochina.com.cn
Guo Yanchen’se-mail: 1398575878@qq.com

Abstract. Nowadays, Longitudinal gravity flow deposits, as a kind of important deep-water reservoirs, can form a certain scale of lithologic oil and gas reservoirs, which is of fundamental significance in the exploration of oil in Saihantala Depression. The evolution and sedimentary characteristics of the longitudinal gravity flow in the east subsag of Saihantala Depression are analyzed based on the core data, well logging, seismic data, regional geological data, and the method of seismic sedimentology. The sedimentary model of the longitudinal gravity flow and the exploration potential of the lithologic reservoir of longitudinal gravity flow are also discussed. The reservoir is mainly composed of medium-fine sandstone with developed secondary pores. The geological conditions for the formation of axial gravity flow are sufficient provenance, the development of slope breaks and the negative axial topography. The updip direction of the longitudinal gravity in the area has a short extension of the sand body, and the downdip direction has thick massive fine sandstones, which opens up pathways for lithologic reservoir exploration.

1. Introduction
Saihantala Sag is located in the middle southpart 5 of Erlian Basin. The northwest direction of the depression is connected with the Sunite uplift; the south is adjacent to the Wendul Temple uplift, and the east is adjacent to the Chaganuoer uplift. It is the largest sag in the Tengger Depression, and it is one of the main rich oil and gas sags in the Erlian Basin. Saihantala Sag has a structure of two depressions, one uplift and one slope. The focus of this study is to study the eastern depression.

2. Sedimentary characteristics of axial gravity flow
2.1. Rocks and Characteristics of sedimentary structures
The second-stage gravity flow deposits in Saidong are mainly sandy conglomerate, including fine conglomerate, fine sandstone and siltstone. The particle size is less than 1cm, and the largest one is 5cm in diameter. The gravels are mostly arranged in a near direction, and the particle size distribution is divided into three stages. The main types of rocks are feldspar and clastic sandstone. The content of cuttings is high, with an average content of 40%, and the composition of interstitial materials is complex. Calcite and clay minerals account for the main components. The debris particles observed
under the flakes are mainly fine particles and medium particles, and the particle diameter is between 0.1mm-2mm. Carbonate and clay minerals are heavily cemented. In addition, illite and kaolinite are mostly distributed in the surface and intergranular pore throats in contact and thin film, which results in a reduction in effective pore throat radius and increases the specific surface area of pore throats. This means that the reservoir rock physical properties have deteriorated. The average porosity in the study area was 10%, and the average pore throat radius was 1.55 μm. The secondary pores such as intergranular dissolution pores and intragranular dissolution pores (Figure 1a, Figure 1b) are mainly used as storage spaces. By coring the V sand group of the Teng 2 Member, it is observed that the sedimentary structures are mainly massive structures, mixing structures, and deformed structures. The mudstone section is mainly gray-black, black layered, and massive mudstone (Figure 1c, Figure 1d, Figure 1e). During the reaction deposition period, the water body is deeper, which is the characteristic of sandy debris flow in typical gravity flow[1].

![Fig.1 Microphotographs and core photographs of longitudinal gravity flow sandstone in Saidongsubsg](image)

2.2. Characteristics of sedimentary microfacies
Sedimentary microfacies such as the main channel under the fan delta, the underwater distributary channel, the fan-leaf complex at the bottom of the lake, and the outer edge of the fan were identified in the study area through the core, logging and seismic data (Figure 2). The fan-shaped delta undercut channel is mainly composed of box-shaped gray thick conglomerate, with obvious erosion structure at the bottom. The seismic reflection shows strong amplitude, high continuity and "V" undercut shape. The underwater diversion channel is mainly gray medium-fine sandstone. The combination of logging curves is bell-shaped; the thickness and scale are relatively poor, and the plane is distributed in a branching divergence. Earthquake reflections exhibit medium-strong amplitude, medium-high continuity, and "U" shaped undercut characteristics. The Yeduo complex mainly develops gray thick fine sandstone. The combination of logging curves is mainly box-shaped and bell-shaped. Earthquake reflections show the strong amplitude and high continuity reflection characteristics. The shape of the plane distribution is controlled by the axial topography, and the contiguous patches are distributed. The outer edge of the fan mainly develops gray-black silty mudstone and mudstone, and the lithology is relatively fine. The combination of logging curves is finger-shaped. Earthquake reflections exhibit weak amplitude and weak continuity characteristics. The physical properties of reservoirs in underwater distributary channels are good, and they are the dominant facies belt for gravity flow exploration.
3. The exploration potential of axial gravity flow lithologic reservoirs

Axial gravity flow deposition is a newly discovered field of lithologic in current exploration work. For lithologic reservoirs, the maturity and supply of hydrocarbon sources, the quality of reservoir physical properties are critical \cite{2,3}. The eastern part of the Saihantala Sag is also the main oil-producing area. The high-maturity source rocks of the Teng 1 Member provide sufficient oil and gas sources for the sand bodies of the V sand group in the upper Teng 2 Member. The two modes of overpressure dredging and fault dredging are formed by the mode of lower generation and upper storage. From the analysis of sedimentary facies, the sedimentary sand body of axial gravity flow in the long axis direction of the study area is mainly the microfacies of Yeduo complex. The maximum thickness of a single sand layer is 4.5 meters, with an average porosity of 12%, and it has the conditions to become a reservoir with good prospects for exploration \cite{4,5}. However, the drilling profile AA shows that along the long axis upslope direction, the sand body is thinner, the physical properties change faster, and the oil shows poorer. The sand body in the down-dip direction has a relatively large thickness and relatively good physical properties (Figure 3). Therefore, the long-axis deposition of the axial gravity flow in the down-dip direction is an advantageous direction to find favorable lithologic traps. From the analysis of storage conditions, the traps formed by axial gravity flow deposition are mainly sandstone lens bodies, which change rapidly in the lateral direction. The boundary of the sand body is obvious, and the advantages of lateral closing conditions are outstanding. At the end of the V sand formation, the water body deepened and the overlying sediments were large, and the mudstone became a good natural cover. Therefore, the axial gravity flow deposited in the V sand group of Teng 2 Member in the study area has superior reservoir-forming conditions and good prospects for exploration.

Fig.3 Well S83-2—well Sai83-1 stratigraphic profile map
4. Conclusion

(1) The sedimentary microfacies of the fan delta undercut main water channel, underwater distributary water channel, Yeduo complex and the outer edge of the fan were identified through the analysis of rock macro and micro characteristics, electrical characteristics, sedimentary structure and seismic reflection characteristics. The Yeduo complex is a favorable sedimentary facies belt with axial gravity flow, and the reservoir has relatively good physical properties, mainly composed of thick sandstone with positive rhythm.

(2) A series of fan delta front deposits are developed on the steep slope of the east depression of the Saihantala Sag, which provides sufficient sources for gravity flow deposition. The development of ancient geomorphic slopes and slope breaks led to the development of large-scale gravity flow deposits inside the depressions. The topography of the depression along the long axis of the sag provides macro-geological conditions for gravity flow in the study area, thus forming a series of axial gravity flow deposits along the axial direction of the depression with the characteristics of pre-productive reflection structure.

(3) The sand body deposited along the long axis down-dip direction has a large scale and thickness, and the reservoir physical properties are relatively good. The trap boundary is obvious, and the preservation conditions are superior. It has superior oil and gas accumulation conditions and broad prospects for exploration. It is an important field for future exploration in the Saihantala Sag in the Erlian Basin.

References

[1] Zou Caineng, Zhao Zhengzhang, Yang Hua et al. 2009. Genetic mechanism and distribution of sandy debris flows in terrestrial lacustrine basin[J]. Acta Sedimentologica Sinica, 27(6):1065-1075.

[2] Qin Jianhua. 1999. Sandy debris flow and bottom current reworking: a new interpretation of the formation of a part of traditional turbidite[J]. Acta Geologica Sichuan, 1999, 19(4): 266-272.

[3] Li Xiangbo, Wei Pingsheng, Liu Huaqing et al. 2013. Discussion on the classification of sediment gravity flow and the deep-water sedimentary model[J]. Geological Review, 59(4): 607-614.

[4] Wang Liuqi, Jiang Zaixing, Cao Yingchang et al. 1994. Sedimentation in fault-trough gravity channel at Shahejie formation of Dongying depression[J]. Journal of China University Petroleum, China, 18(3): 19-24.

[5] Zhang Na, Jiang Tao, Zhang Daojun. 2012. Topography and its control over deepwater sedimentary in the Qiongdongnan Basin[J]. Marine Geology & Quaternary Geology, 32(5): 27-3