The Reservoir Characteristics Study on Yingshan Formation of the Ancient City-Lowuplift in Tarim Basin

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Abstract. The oil and gas exploration has been broken through in ordovician-Yingshan formation of the lower Paleozoic in ancient city-low uplift, in Tarim Basin. The preliminary study found that the rich oil and gas resources are mainly in karst cave of the dolomite reservoir. It is revealed that the exploration potential of the carbonate reservoir in Yingshan formation of the ordovician. So, the systematic evaluation and study on the carbonate reservoir for Yingshan formation of the Ordovician in ancient city-low uplift have been done. Based on the analysis of drilling, logging, well logging and testing data, it is found that: The reservoir spaces of carbonate reservoir of ancient city area are mainly intergranular pore, intergranular dissolved pore, karst cave, structural fracture and diagenetic fracture. The reservoir of Yingshan formation in the ancient city area is mainly crack pore-cave reservoir, secondly fracture type reservoir, and the porosity for the third section of Yingshan formation is relative development with large thickness which should be the key exploration target. The dolomite reservoir of Yingshan formation has the characters of multi layers, thin layers vertically and the different comparison in horizon. The lower part of high-quality dolomite reservoir in Yingshan formation is an important exploration area of carbonate reservoir in ancient city-low uplift. The studies, on the micro and macro development characteristics of the carbonate reservoir of ordovician-Yingshan formation in ancient city-low uplift, provide ideas and guidance for the exploration and deployment of the carbonate reservoir.

1. Introduction

Ancient city-low uplift is located in south central northern depression zone in Tarim Basin, the east tower uplift adjacent to the east, the central tower uplift adjacent to the west. After the Gucheng 1 well scrapped in 1996, Gucheng 2 well, Gucheng 3 well and Gucheng 4 well has not been successful. The Gucheng 6 well which was drilled in 2012 and the Gucheng 8 well which was drilled in 2013 have obtained commercial gas flow in ordovician-Yingshan formation. It shows that ordovician-Yingshan formation which is located in the starved basin phase has exploration prospects of forming the scale gas reservoirs. The reservoir evaluation and research of ordovician-Yingshan formation are still blank. Therefore, this article on ordovician-Yingshan formation reservoir is researched systematically.

2. The General Geology

The whole structure of ancient city-low uplift is north east tending to be large nosing structure, northeast part is high and southwest part is low. It developed a series of north-trending tension-shear normal faults in large nosing structure of ancient city-low uplift. These faults cut the large nosing
structure into the horsts and grabens structures. Local traps are developed on horsts and grabens, such as fault block, fault nose and anticline.

According to drilling data revealed, formations from top to bottom in ancient city-low uplift are Quaternary System, Tertiary System, Cretaceous System, Triassic System and Ordovician System Queerqueke formation, Tumuxiuke formation, Yijianfang formation, Yingshan formation and Penglaiba formation, Cambrian system. Jurassic, Permian, Devonian and Silurian are sequence missing. Yijianfang formation is a set of underlying limestone reservoir, and Yingshan formation, Penglaiba formation and Cambrian system are three sets of dolostone reservoirs. The dolostone reservoirs in the third section of Yingshan formation have been got breakthrough that they could form scale distribution of carbonate reservoirs.

3. Reservoir Characteristics

3.1 Petrologic Characteristics

According to drilling data in ancient city-low revealed, Queerqueke formation is extremely thick clastic sedimentary, about 2000m~3000m, and lithology is mainly mudstone, argillaceous siltstone and silty mudstone. The lithology of Tumuxiuke formation is brown gray argillaceous limestone, drilled thickness about 31m. Tumuxiuke formation is the marker bed of Ordovician System with the thickness of 14.5~34.5m, usually about 20m. The lithology of Yijianfang formation is mainly brown gray sparry arenite calcirudite and sparry oolitic calcarenite, and reservoir property is poor. Yijianfang formation is unconformity contact with Yingshan formation, with the possibility of developed surface karst belt. The first section of Yingshan formation is mainly microcrystalline micrite and sparry calcarenite, and the sedimentary facies is carbonate platform edge facies sediment with the possibility of developed marginal arenite beach. The second section of Yingshan formation is mainly micrite, sparry calcarenite, and the sedimentary facies is carbonate platform edge facies sediment with the possibility of developed marginal arenite beach. The third section of Yingshan formation is mainly calcarenite, micrite, fine crystal-microtek-coarse grain dolomite (dolomitic limestone or calcite dolomite), crystal powder-fine crystal-microtek-coarse grain dolomite, and a small amount of sparry calcarenite. The sedimentary facies is carbonate platform edge facies sediment. The fourth section of Yingshan formation is mainly sparry calcarenite with microtek to fine grain (calciferous or calcite) dolomite secondly, and the sedimentary facies is carbonate platform edge facies sediment with the possibility of developed marginal arenite beach. The upper section of Penglaiba formation is mainly sparry calcarenite, and the lower section is mainly microtek to fine grain (calciferous or calcite) dolomite. The lithology of Cambrian system is mainly gray dolomitic limestone, calciferous dolomite and calcite dolomite.

3.2 Reservoir Space Type

According to the analysis of common slice and casting slice, the types of The carbonate rock pores in Ordovician System Yingshan formation in ancient city-low uplift are primary intergranular pore, secondary pore, cavern, structural fracture and diagenetic fracture [3-8]. Secondary pores include intracrystalline pores and intergranular dissolved pores, and are mainly distributed in the third and fourth section of Yingshan formation. Caverns only develop in the third section of Yingshan formation. Primary intergranular pore, structural fracture, pressure solution joint and diagenetic fracture develop from the first section to fourth of Yingshan formation. Part of the secondary reservoir space is occupied by bitumen. The third section of Yingshan formation is advantageous to the enrichment of oil and gas reservoir space.
### Reservoir space types

| Reservoir space types          | Size                  | Effectiveness evaluation | Reservoir space micro characteristics | Horizon distribution |
|--------------------------------|-----------------------|--------------------------|----------------------------------------|-----------------------|
| Pore                           |                       |                          |                                        |                       |
| Primary intergranular pore     | Primary intergranular pore | /                        | Gc 7 6140m                             | Gc 8 6063m            | First section to fourth |
| Secondary pore                 | Intracrystalline pores <2 mm | Bitumen                 | Gc 7 6110m                             | Gc 8 3-2-2m           | Third and fourth section |
|                                | Intergranular dissolved pores | effective               | Gc 7 6192.3m                           | Gc 8 6401.3m          | Third and fourth section |
| Hole                           | Cavern                | /                        | effective                              | /                     | Third section           |
| Fracture                       | Structural fracture   | /                        | Gc 7 6161m                             | Gc 8 5810m            | First section to fourth |
| Diagenetic fracture            | Pressure solution joint | /                        | Gc 7 6184m                             | Gc 8 6059.2m          | First section to fourth |
|                                | Diagenetic fracture   |                          | Gc 7 6023m                             | Gc 8 6071m            | First section to fourth |

**Figure 1.** Reservoir space types for Yingshan formation of Ordovician in ancient city-low uplift

### 3.3 Reservoir Type

Through the analysis to the sidewall coring and common slice and casting thin sections data of core in the ancient city, the carbonate rock microcosmic reservoir space has different combinations. According to the logging response, it can be divided into hole type, fracture type and crack pore-cave type. Classifying reservoir to calculate statistics, we find that the reservoir of Yingshan formation in the ancient city area is mainly crack pore-cave reservoir, accounted for 47.54%. Secondly fracture type reservoir, accounting for 42.26%. The preliminary analysis that the continuous deposition of ancient city-low uplift Ordovician System Yingshan formation, Yijianfeng formation, Tumuxiuke formation cause Yingshan formation without exposed in the leaching and later, weathered and denuded, crack hole system development is limited, and do not develop large cave.
3.4 Reservoir Physical Property

The study on logging interpretation of porosity of ancient city-low uplift Ordovician System Yingshan formation, reservoir porosity of the third section of Yingshan formation is relatively developed and large thickness, porosity is relatively developed but thin at the bottom of the fourth section of Yingshan formation. Therefore, Ordovician system the third section of Yingshan formation is the favorable oil and gas accumulation horizon, should be the focus of exploration targets in this region.

4. Reservoir Evaluations

Based on the analysis, the ancient city-low uplift reservoir matrix porosity is poorer, matrix reservoir space for oil and gas reservoir and the contribution of production is not big, reservoir storage capacity and is closely related to the development degree of reservoir cracks and holes(9-13). On the basis of existing research results, comprehensive reservoir development characteristics of the ancient city area, carbonate reservoir region can be divided into three categories (table 1).
Table 1. The classification standards for Carbonate reservoir of ancient city area in Tarim Basin

| Reservoir category | Effective porosity (%) | Fracture porosity (%) | The main reservoir type |
|--------------------|------------------------|-----------------------|------------------------|
| I                  | $\Phi_e \geq 5$        | $0.1 \leq \Phi_f < 1$ | Crack pore-cave        |
|                    | $1.8 \leq \Phi_e < 5$  | $0.04 \leq \Phi_f < 0.1$ | Crack pore-cave type  |
|                    | $5 \leq \Phi_e < 10$   | $\Phi_f < 0.04$       | Hole type              |
| II                 | $\Phi_e < 1.8$        | $0.1 \leq \Phi_f$     | Hole type              |
| III                | $\Phi_e < 1.8$        | $0.04 < \Phi_f < 0.1$ |                        |

According to well logging interpretation of porosity and fracture porosity, the reservoir property analysis data, coring segment core seam hole observation statistics and data, the reservoir classification standard, the effective reservoir of ancient city-low uplift Ordovician System Yingshan formation evaluation is analyzed (table 2).

Table 2. The effective reservoir thickness tab for Yingshan formation of Ordovician in ancient city area

| Well NO. | Formation | First section | Second section | Third section | Fourth section | Total |
|----------|-----------|---------------|----------------|---------------|----------------|-------|
| GC 4     | II        | 117           | 17.5/3         | 209           | 0.084          | 178   |
| GC 6     | II        | 157           | 178            | 45/8          | 15.4/2         | 178   | 2/1  | 0.549       | 110 | 0.065 | 628 | 0.041 |
| GC 7     | II        | 128           | 186            | 9.8/4         | 212            | 110   | 0.046 | 3.6/1   | 212 | 0.142 | 699 | 0.049 |
| GC 8     | II        | 106           | 190            | 17.2/2        | 131            | 212   | 182   | 0.131   | 131 | 0.041 | 609 | 0.028 |

Ancient city-low uplift Ordovician System Yingshan formation characteristics of carbonate reservoir development distribution:

1. Carbonate reservoir of ancient city-low uplift Ordovician System Yingshan formation is given priority to with effective reservoir II class, followed by III reservoir.
2. In ancient city area, the statistical results of the ratio of effective reservoir thickness and formation of single well from Ordovician System Yingshan formation show that, the first section of Yingshan formation is not developed, the second section of Yingshan formation is local development II kind of reservoir and the ratio of the reservoir to formation is low. The third and fourth section of Yingshan formation is main development II kind of reservoir and the ratio of the reservoir to formation is relatively high, local development III kind of reservoir. The favorable reservoir in carbonate reservoir of ancient city-low uplift on the longitudinal mainly concentrated in the third and fourth section of Yingshan formation.
3. According to drilling data, ancient city-low uplift Ordovician System Yingshan formation is a set of complete assemblages, the first and second section of Yingshan formation develop a set of limestone, that effectively block the oil and gas of lower the reservoir in Yingshan formation. Lower Yingshan formation develop a set of dolomite reservoir and reservoir effective thickness is not high, has the characters of multi layers, thin layers on the longitudinal and the different comparison on the transverse.

5. Conclusions

1. The reservoir space types from the first section to fourth of Yingshan formation in ancient city-low uplift are mainly primary intergranular pore, structural fracture and diagenetic fracture.
2. The reservoir of Yingshan formation in the ancient city area is mainly crack pore-cave reservoir, secondly fracture type reservoir.
3. The porosity for the third section of Yingshan formation is relative development with large thickness which should be the key to exploration target.
(4) Ancient city-low uplift Ordovician System Yingshan formation is a set of complete assemblages, the reservoir is mainly focused on the part, reservoir level for II. Dolomite in the Yingshan formation part on the lateral lithology continuous, but effective dolomite reservoir has the characters of multi layers, thin layers on the longitudinal and the different comparison on the transverse, which is a local beaded development and has formed the scale gas reservoir potential.

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