In recent years, the marine carbonate hydrocarbon exploration presents a momentum of rapid development in China and have found a number of large oil and gas fields, especially recently in the northern area of Tarim basin, the large Rewapu oilfield was found at the depth of 7000m in the Ordovician carbonate rocks, showing the great exploration potential in deep and ultra deep of Tarim basin. The results indicate that reservoirs of Rewapu oilfield are low porosity and low permeability layers karst reservoirs, reservoir temperature is around at 160℃ with oil, and the crude oil comes from the upper Ordovician source rock of the Manjaer depression. The hydrocarbon accumulation time is in the Late Permian, and since the Triassic sedimentary, the reservoir is in the continuous process of burying. It belongs to the old oil and gas system. The Ordovician carbonate reservoir in Rewapu was a fracture-cavity pool controlled by interbedded karst reservoirs, and the Oil and gas distribution and enrichment are not controlled by the local tectonic, but by the distribution and the development degree of Ordovician carbonate reservoir. The reservoir development degree was controlled by the karstification, the degree of fracture development and the sedimentary facies. The reservoirs of Rewapu block are mainly distributed in the Ordovician Yijianfang formation and at the top Yingshan formation, concentrating into belts in plane and not controlling by the depth in the vertical. The overlying strata are limestone of Tumuxiuke formation and marls and limestone of Sangtamu formation in Ordovician, both of which are of a good reservoir-cap assemblage.

The high production of the RP3 well which is the discovery well in the Rewapu oilfield marks a breakthrough in the Ordovician in the Rewapu area. RP3 well which is located in the south dumping site of the nose structure is the first industrial oil well in the Lunnan-Yingmaili carbonate buried hill that the reservoir’s depth is below 7000m. It breakthrough the high and stable yield of the carbonate reservoir with 7000m depth. And further confirm the characteristics that the distribution of the Ordovician hydrocarbon which is not controlled by the local structure, rich oil and gas in Lunnan-Yingmaili area, and the quasi-layered pool of local enrichment(Zhu et. al.,2011). It is confirmed that the south Tabei uplift that depth is below 7000m is still favorable exploration area, and greatly expanded the carbonate hydrocarbon exploration area of south slope.

1 The petroleum geologic features of large Rewapu oilfield

The Rewapu block is located in the northern slope zone of the Halahattang depression in Tabei uplift of Tarim basin. To the north of the Rewapu block is the Ha6-Xinken block, and to the south is the Manjiaer depression. And it is located in the front of the main direction of oil and gas migration. The faults are more complex of the Palaeozoic in Rewapu block for the vertical fault, multiple activities and slip characteristics. Horizons are from Permian to the substrate, the fault distance is 30~70m, plane extension is 10~30km. These faults played an important role in the superimposition of the Ordovician karst reservoir development, which were formed in late Caledonian-Hercynian. The main reservoirs are Yijianfang formation and Yingshan formation which are under the Tumuxiuke formation of the Ordovician in Rewapu oilfield, and the oil and gas are found in few Lianglitage formation. And the cap is composed of the marlstones of overlying Tumuxiuke formation and marls and marlstones of Sangtamu formation in Ordovician, both of which are of a good reservoir-cap assemblage.

Temperature and pressure system of Rewapu reservoir


ZHU Guangyou¹, LIU Xingwang¹, SU Jin¹ and YANG Haijun²

1 PetroChina Research Institute of Petroleum Exploration and Development, Beijing 100083, China
2 PetroChina Tarim Oilfield Company, Korla 841000, China

In recent years, the marine carbonate hydrocarbon exploration presents a momentum of rapid development in China and have found a number of large oil and gas fields, especially recently in the northern area of Tarim basin, the large Rewapu oilfield was found at the depth of 7000m in the Ordovician carbonate rocks, showing the great exploration potential in deep and ultra deep of Tarim basin. The results indicate that reservoirs of Rewapu oilfield are low porosity and low permeability layers karst reservoirs, reservoir temperature is around at 160℃ with oil, and the crude oil comes from the upper Ordovician source rock of the Manjaer depression. The hydrocarbon accumulation time is in the Late Permian, and since the Triassic sedimentary, the reservoir is in the continuous process of burying. It belongs to the old oil and gas system. The Ordovician carbonate reservoir in Rewapu was a fracture-cavity pool controlled by interbedded karst reservoirs, and the Oil and gas distribution and enrichment are not controlled by the local tectonic, but by the distribution and the development degree of Ordovician carbonate reservoir. The reservoir development degree was controlled by the karstification, the degree of fracture development and the sedimentary facies. The reservoirs of Rewapu block are mainly distributed in the Ordovician Yijianfang formation and at the top Yingshan formation, concentrating into belts in plane and not controlling by the depth in the vertical. The overlying strata are limestone of Tumuxiuke formation and marls and limestone of Sangtamu formation in the upper Ordovician.

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2 Temperature and pressure system of Rewapu reservoir


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3 Deep sedimentary reservoir features and formation mechanism

There are five kinds of facies belts during the sedimentary of Ordovician Yingshan formation Ying-1 member–Sangtamu formation in Rewapu area: open platform facies, platform margin facies, sinking platform facies, slope facies and shelf facies. During the Ordovician, the deposition in the Rewapu block experienced a process from seawater becoming shallow in the Yingshan-Yijianfang formation open platform to seawater becoming deep in the Tumuxiuke formation submerged platform–slope facies, Lianglitage Formation platform margin and Sangtamu Formation mixed shelf. The dominant rocks are grain limestone, micrite grainstones, grain micrites, micrites, biogenic limestones, nodular limestones, and so on.

The porosities and permeabilities of Yijianfang formation logging interpretation are very low, the porosities the are 0.108~12.175 %, averaging 5.40%, and the porosities of 40% samples are between 1.8~4.5%, 42% samples are more than 4.5%. The permeabilities are 0.001~0.112×10⁻³ μm², averaging 0.02×10⁻³ μm², with 65% samples being more than 0.01×10⁻³ μm². It can be seen that the porosities of carbonate matrix are poor in this area, the reservoirs are of fractures and caves with strong heterogeneity, and fractures contribute to permeabilities greatly. The excellent reservoirs are mostly in the range of 0~100m below the weathering crust. The formation and development of the Ordovician carbonate reservoirs in Rewapu area are mainly controlled by the unconformity karst, and then by tectonic fault reconstruction, sedimentary environment and rock type etc. The unconformity karst was mainly happened between Yijianfang formation and Tumuxiuke formation. After the Yijianfang formation was deposited, structures were uplifted and eroded, the top surface formed a low angle unconformity. The strata below the top of Ordovician Yijianfang formation suffered a large area of leaching, forming a great number of dissolved pores (Loucks, 1999) and cavities, caves, and corroded fissure which are the main storage and permeation spaces. So the reservoirs are mostly in the range of 70-100m below the top of the Yijianfang formation, and have a good layer, characterized by vertical overlap, cross linked.

4 Source and Origin of Oil and Gas

The data of fluid properties of the Rewapu oilfield shows that the density of Ordovician oil is 0.7853~0.8743g/cm³ (20°C), averaging 0.8082 g/cm³. The dynamic viscosity of oil 50°C at is in the range of 1.46~5.46 mPa.s, averaging 1.82mPa.s, it is oil of low viscosity. The oil has a wax content of 6.1~10.1%, averaging 7.3%, being high-wax oil. The content of colloid and asphaltene is 0.58~8.49%, averaging2.78%. It can be seen that the oil is light oil with low viscosity and high wax. The methane averaging content is 75.24%; the averaging content of ethane and above is 18.37%; and the nitrogen averaging content is 3.21%; the carbon dioxide averaging content is 3.12%. The gas has the characteristics of wet gas, is oil associated gas.

By analyzing the methyl triaromatic steranes in oil source biomarkers and their distribution in the Rewapu area, we find that almost all the wells in this area do not contain 4, 23, 24-trimethyl triaromatic steranes, but 3-methyl-24 ethyl triaromatic steranes are very significant. Meanwhile, the contents of C2520S and C2520R triaromatic steranes are high, whereas the contents of C2620S, C2620R, C2720S, and C2720R triaromatic steranes are very low. These features are obviously the same as those of the Middle and Upper Ordovician oil (Handson et. al., 2000; Zhang et. al., 2002), but different from those of the Cambrian oil. The Middle and Upper Ordovician source rocks in Rewapu area are mainly distributed in the southern slope of Tabei uplift and the transition zone between Awati and Manjiear. The deep Rewapu oilfield in the southern Tabei uplift captured the oil and gas generated by the Middle and Upper Ordovician source rocks(Zhu et. al., 2012a).

5 Process and Pattern of Oil and Gas Accumulation

There are two sets of effective hydrocarbon source rocks in marine sedimentary association of inner Tarim basin: Cambrian-Lower Ordovician (referred to as the
Cambrian source rock), and Middle-Upper Ordovician source rock. Because of the difference of distribution location of these two sets of marine hydrocarbon source rocks, the histories of hydrocarbon generation and expulsion also have obvious difference.

The Cambrian source rock evolved rapidly, generated hydrocarbon early and entered the stage of maximum hydrocarbon expulsion in the Late Caledonian (Late Silurian). But the Middle-Upper Ordovician source rock on the contrary, and entered the stage of maximum hydrocarbon expulsion in the Late Hercynian (Late Permian) (Zhang et. al., 2011). According to oil-source correlation, the Ordovician carbonate reservoirs in Rewapu area captured the oil and gas generated by the Middle and Upper Ordovician source rocks. Therefore, the effective accumulation of the oil and gas might take place in the Late Hercynian (Zhu et. al., 2013).

The data of inclusions in the Halahatang oilfield (Zhu et. al., 2012b), which is close to the Rewapu oilfield, also confirms that the homogenization temperature which distribution is in 75–105 °C, is low, and the distribution concentrated of Ordovician organic inclusion of Ha9 well. Burial history curve plotted by restoring strata denudation shows that the main accumulation time is from the middle and late period of the Permian to the time when the Triassic was deposited, i.e., the Late Hercynian. It is consistent with the analysis of this oil source results.

So, it can be determined that the accumulation time of the Rewapu oilfield was in the Late Hercynian according to the hydrocarbon-generating history, oil-source correlation, inclusions data and the comparison with the adjacent area. The Late Hercynian is one of the most important stages of hydrocarbon generation and hydrocarbon expulsion, and also is the most effective accumulation period in Tarim Basin. The hydrocarbon generated from the Middle and Upper Ordovician source rocks of the south of Tabei Uplift migrated northwards, charged into the Ordovician karst reservoirs, and formed a large-scale oil and gas pool. In the tectonic movement before the Triassic sedimentary, however, oil of Ordovician was oxidized and degraded. Due to serious erosion of the cover, the oil reservoir damaged in structural high part, the oil and gas are preserved in slope, but the crude oil generally suffered biodegradation. After that the oil pool was deeply buried and the overlying strata thickened. Although it has never again to capture oil and gas in the Triassic, the oil and gas pool has been successfully kept till present for the good preservation conditions.

In the south of Rewapu area, although the Ordovician reservoir depth is deeper, but reservoir quality is very good. This area is in the path of oil and gas migration to the north, and has the same characteristic of oil with Rewapu. There is a great resource potential, so I suggest to carry out the favorable target evaluation as soon as possible and speed up the pace of deep exploration.

Key words: deep, quasi-layered pool, carbonate rocks, marine, Rewapu, Tarim basin

Reference


