China marine petroleum basins developed mainly in Palaeozoic were complex in hydrocarbon distribution, experiencing multi-cycle sedimentation and tectonic movement (Zhao et al., 2007; Jin, 2005; Zhu et al., 2007). Especially for carbonate layer, deep bury, heterogeneous reservoir, ancient hydrocarbon source rocks, high thermal evolution, complex accumulation process et al. bring great difficulty in predicting for marine hydrocarbon distribution, which has restricted marine carbonate oil and gas exploration. Tazhong is located in the central of Tarim basin, being a part of the central uplift belt which is a inheritance palaeohigh developed during a long period. Tazhong is the key area exploring for hydrocarbon and Ordovician is the important exploration system. From 1989 to 2002, 52 wells were drilled totally but oil was found only in several wells, such as TZ1 well. Since 2003, based on newly acquired 3D seismic data and other new technologies, the marine hydrocarbon exploration potential and favorable areas has been understanding again and the carbonate large gas condensate field has been discovered in O3l along Tazhong NO.1 break fault (Zhou et al., 2006). In 2006, by exploring the lower Ordovician, highly productive oil flow was obtained in TZ 83 well and Karst unconformity in O1y was discovered. Recently, the third geological reserve has reached 1 billion tons (Oil equivalent). By research and exploration, the follow ideas are obtained: Tazhong area is rich in both oil and gas; reef complex, karst weathering crust and the lower Paleozoic dolomite are the focus area for increasing production; the oil and gas resources maybe more than 5 billion tons.

1 reservoir characteristics

The Ordovician rocks are mainly limestone. According to the rock physical properties and log interpretation, reservoir types in Tazhong are mainly secondary cracks holes reservoir, primary porosity is not development. Statistics on the core-measured physical data found the follows: generally, core matrix porosity < 1.8%, accounting for 80.69% and the other > 1.8%, accounting for 19.31%. Penetration < 0.01×10^-3 μm², accounting for 4.46% and the other > 0.01×10^-3 μm², accounting for 95.54%.

The Ordovician reservoir appears large area laterally and is inhomogeneous in longitudinal. Effective reservoir developed in O1y, mainly distributed in the top of O1y, especially 140m within the scope of below unconformity, the max reservoir thickness up to 64.9m. The reservoir which is the principal production layer is continuity on lateral and appeared multi-phase stacking longitudinally.

In the five members of O3l, O3l2 reservoir properties are best, then O3l1 and O3l3, final the O3l4 and O3l5. In O3l1 and O3l3, there are reef complex, mound beach complex phase biolithite and grain limestone, about 80-300m. There are beach marine micritic limestone, grain crumbs micrite, which are important reservoirs, about 30-80m.

Based on the microscopic study on cast thin, Micro-reservoir space types includes mainly intragranular dissolved pore, moldic pore, intergranular dissolved pores, intercrystal pore, microcrack and so on. Primary pore of Tazhong reservoir developed bad, reservoir space are mainly secondary reservoir, such as pores, holes and fractures. By the reservoir space combined features characteristics, reservoir types can be divided into four kinds: cavernous reservoir bed, pore-cave reservoir bed, fracture-pore-cave reservoir bed and fractured reservoir bed. On the basis of log interpretation, Ordovician reservoir are mainly pore-cave reservoir bed and fracture-pore-cave reservoir bed.

2 hydrocarbon distribution characteristics

There are three kinds of reservoir: condensate reservoir,
volatile oil reservoir and formal oil reservoir. Condensate reservoirs are the based ones and the other are supplemented. For the horizontal distribution, GOR and oil/gas production capacity distribution of different type reservoirs are regularity. In the eastern part and areas near the NO.1 fault zone, GOR is universally high and a large number of gas wells located there, while low GOR wells located mainly in mid-east and western platform area. Judging from the structural position, low GOR wells are located in western platform where faults developed bad, or in isolated fault block or in relatively low site where strike-slip fault didn’t developed. For example, ZG501 and ZG432 are located in isolated fault block; ZG13 is located in relatively low site. High GOR wells are mainly located in relatively high site, near Tazhong NO.1 structure belt or NE-SW strike-slip faults, especially the cross-site of strike-slip fault and Tazhong NO.1 structure belt. The boundaries between high GOR wells and low GOR wells are not obvious.

Hydrocarbon show and hydrocarbon characteristics present multi-layer system in the longitudinal direction. O1y is obviously higher than O3l in the content of hydrogen sulfide and carbon dioxide in natural gas. The dry coefficient difference is not obvious between the two formations, but O1y has a higher proportion of low dry coefficient gas. Generally, O3l gas is dryer and has a lower content of heavy hydrocarbons than O1y. By the statistics and analysis for O3l high-yield gas wells, follows are found: natural gas dry coefficient is 0.8276–0.9939, and average 0.9577; CH4 contend is 73.9–98.2%, and average 86.9%; C2H6 and other 0.604–15.39%, and average 3.76%; N2 contend is 0.56–18.1%, and average 6.68%; CO2 contend is 0–8.63%, and average 2.64%; H2S contend is 1.4–115000mg/m³, and average 11650mg/m³. Generally, the O3l gas is low N2 contend, middle CO2 contend, low H2S contend dry gas. For the crude oil characteristics like this: multi-layer system longitudinally and obvious heterogeneity laterally. Multiple structure movement and sedimentary evolution are the fundamental reason for the composite reservoir formation; multiple source rocks and multiple hydrocarbon charging are base of complex reservoir; inhomogeneous geology condition, especially faults and reservoir, is the direct reason for multiple types reservoirs and its complex distribution.

Three hydrocarbon chargings occurred totally in Tazhong area and each charging is different in spatial distribution and fluid state(Zhang et. al., 2011). Late Caledonian, extensive crude charging occurred in Ordovician and Silurian, because of which reservoirs were formed in some favorable areas. But because of shallow depth and bad cap rock, hydrocarbon fluid lost continuously. The later early Hercynian tectonic movement resulted in the uplift of this area, which resulted in the strata eroded, cap damaged, reservoir damaged. So the late Caledonian crude oil was damaged seriously, only residual asphalt was founded in local area. Therefore, this oil charging’s effect on condensate reservoir nowadays is negligible.

Late Hercynian is the most important and most effective accumulation period for Tazhong area. Source rocks from the Upper Ordovician started releasing hydrocarbon. The uplift resulted from continued uplift is favorable for fluid accumulation and multi-layers in Tazhong were accepted hydrocarbon charging. Later small-scale tectonic movement had faint adjustment and damage to late Hercynian reservoirs. Oil reservoirs preserved are almost formed in late Hercynian (Zhu et. al., 2012; 2013).

Gas cutting in late Himalayan reformed the late Hercynian reservoirs seriously. Since Cenozoic, Tazhong area have received thick deposition, accelerating the deep marine hydrocarbon resource rock diagenetic evolution and crude oil cracking(Zhang, 2000). High mature oil cracking gas from Cambrian migrated along late Hercynian strike-slip fault from up to down, which reformed the ancient reservoirs seriously.

Because of the obvious heterogeneity of reservoir and structure, gas cutting’s effect on reservoirs in different area is different: oil reservoirs near gas conductivity faults, with good reservoir, received greater degree of gas invasion, becoming condensate reservoirs finally; ancient oil reservoirs far from gas conductivity faults, with closed reservoir, received weak gas invasion, becoming formal oil reservoirs or volatile oil reservoirs. So, condensate oil reservoirs in Tazhong area are secondary type condensate gas reservoirs resulting from late gas invasion.

In short, both the upper Ordovician Lianglitage formation reef complex and Yingshan formation weathering crust reservoir in Tazhong have the

3 The accumulation mechanism of the large area quasi-layered complex reservoir

Complex reservoirs in Tazhong area present the
characteristics of “large area, layered distribution and rich in hydrocarbon overall”. Ordovician oil is mix-sourced of Cambrian and Ordovician, natural gas are mainly high maturity oil cracking gas from mid-lower Cambrian (Jiang et al., 2008). The condensate reservoir accumulation process includes three periods: mid-late Caledonian, late Hercynian oil charging and Himalayan gas charging. Ordovician condensate reservoir is formed because of late gas invasion: oil cracking gas from Cambrian invaded the ancient oil reservoir; Multi-source, multi-phase accumulation and multi-period adjustment are the primary cause for oil mixed-source. Two sets of hydrocarbon source rocks and three stages of hydrocarbon expulsion provided great resource potential for Ordovician accumulation in Tazhong. Many sets of carbonate reservoirs of high quality formed in Ordovician because of structure and karstification. The mesh oil and gas transporting system formed by fault, unconformity and fracture-cave zone brought about the universal complex hydrocarbon accumulation in Tazhong ancient uplift. The palaeohigh developing stably in a long term provides favorable conditions for the extensive hydrocarbon accumulation in Tazhong Ordovician. Ordovician reef complex and the weathering crust in Yingshan formation of lower Ordovician are two realistic exploration fields in the near future and the hydrocarbon resource potential is great.

Key words: large area, quasi-layered, carbonate, complex, accumulation mechanism, Tazhong

References