Research article

Ordovician gas exploration breakthrough in the Gucheng lower uplift of the Tarim Basin and its enlightenment

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Received 5 December 2013; accepted 25 January 2014

Available online 1 November 2014

Abstract

A steady high yield natural gas flow was tapped in the Ordovician strata of Well Gucheng 6 drilled in the Gucheng lower uplift in the Tarim Basin in 2012, marking the discovery of another carbonate gas exploration field after the other two fields in the middle and northern Tarim Basin (the so called Tazhong and Tabei in the industry). The exploration in the Gucheng lower uplift has experienced three stages: the first stage, marine facies clastic exploration from 1995 to 2003, focusing on the Devonian Donghe sandstone lithologic traps, the Silurian overlapping lithologic traps, and the Upper Ordovician shelf slope turbidites; the second stage focusing on the reef shal carbonate reservoirs from 2003 to 2006, during which oil and gas were first discovered in Well Gucheng 4; the third stage can be divided into two periods, in the first period, deeper insight into interbed karstification reservoir exploration, intense research on tricky seismic issues, selection of favorable zones, and 3D seismic deployment in advance laid a robust foundation for breakthroughs in oil and gas exploration; and during 2009—2012, through an in-depth investigation, Well Gucheng 6 was drilled, bringing about the major breakthrough in oil and gas exploration in this study area. This success proves that the Lower Paleozoic carbonate rocks in the Gucheng area have good geological conditions and broad prospect for oil and gas exploration, which give us enlightenment in three aspects: a. new insight into geologic understanding is the prerequisite of exploration breakthrough; b. addressing bottleneck technologies, and acquiring 3D seismic data are the guarantees of exploration breakthrough; and c. emancipation of mind and persistent exploration are key to the findings in new domains.

Keywords: Tarim Basin; Gucheng uplift; Exploration breakthrough; Exploration history; Exploration prospect; Enlightenment

Located at the south margin of Manjiaer hydrocarbon generating sag, Tarim Basin, Gucheng area has good paleo-structure settings and superior reservoir-seal assemblages, so it has excellent petroleum geologic conditions. Since the Tarim petroleum E&D campaign from 1989 to 2011, although Gucheng area is not main battlefield of exploration, there was still some workload every year, totally 1.45 × 10⁴ km of 2D seismic and 174 km² of 3D seismic; 14 wells have been drilled, among which one well had gas shows and another one tested low oil production, but lower than industrial standard. In 2012, high production gas flow was tapped in Gucheng-6 from the dolomite series in the Ordovician Yingshan Fm., which, as the first breakthrough in Gucheng area after 23 years of exploration and also the first major breakthrough in the inner dolomite of the Lower Paleozoic across the Tarim Basin, is of great significance. Based on the analysis on the natural gas exploration history of the Gucheng area, the exploration approach to the discovery of gas field Gucheng-6 has been sorted out, in the hope to direct the exploration in other blocks.

1. Geologic background

The Gucheng lower uplift is separated from the Tazhong uplift by fault Tazhong I in the southwest, linked with the southeast uplift by Upper Cambrian—Lower Middle Ordovician slope break in the east, and close to the Manxi lower uplift in the North depression in the north (Fig. 1). The Gucheng lower uplift, being the Lower Paleozoic large wide nose structure dipping to the northwest, comprises two parts: the southeastern part,
strongly influenced by the Cherchen fault, developed a series of complex thrust structures, and the northern part, weakly influenced by the Cherchen fault, developed gentle structures that are faulted anticlines in local areas.

Seismic and drilling data reveal that the Lower Paleozoic strata in the Gucheng lower uplift are complete and more than 5000 m thick; while in the upper Paleozoic, the Silurian and Devonian distribute in a limited range mainly in the north of Gucheng nose uplift, and the Carboniferous is distributed widely, yet the Permian is absent; Mesozoic, about 1000 m thick, mainly includes Triassic and Cretaceous, yet no Jurassic; the Cenozoic, about 1800 m thick, is distributed stably. The stratigraphic truncation and overlapping show that there are four angle unconformities in the Gucheng low uplift: Silurian/Ordovician angle unconformity; angle unconformity between Carboniferous and the underlying formation; angle unconformity between Triassic and the underlying formation; and angle unconformity between Cretaceous and the underlying formation (Fig. 1).

It can be seen from the angle unconformities that the Gucheng lower uplift is a long inherited paleo-uplift structure, mainly experiencing four stages of tectonic movements, including Caledonian, mid Hercynian, early Indosinian and Yanshan periods, and the tectonic movement has weakened from Yanshan period to now. (1) In the Caledonian (pre-Silurian), the growth of foreland basins around the basin brought about the embryonic shape of the Gucheng lower
uplift which was higher in the south and lower in the north, and the Silurian deposits overlapped from north to south; (2) in the mid Hercynian (pre-Carboniferous), the paleo-structure in the Gucheng lower uplift underwent the second movement, resulting in the uplift of the south part and thus erosion of Ordovician, Silurian and Devonian to various degrees, and Carboniferous overlying on them; (3) in the early Indosinian epoch (pre-Triassic), the paleo-structure in the Gucheng lower uplift experienced movement again, leading to the continuous erosion of Paleozoic, and Triassic overlying on the Permian and Carboniferous unconformably; (4) in the Yanshan (pre-Jurassic), due to the rise of Tadong and Tadongnan, the Triassic in the Gucheng lower uplift suffered erosion to some extent, resulting in Cretaceous overlapping on the Triassic; and (5) in the Himalayan, the area, weak in tectonic movement, steady in basin settlement, received thick terrestrial Cenozoic deposits, and finally formed the present shape.

There are three major exploration domains in the Gucheng lower uplift: Upper Paleozoic marine clastic rocks represented by Carboniferous Donghe sandstones and Silurian sandstones; reef-type carbonate rocks in the Upper Cambrian—lower Ordovician slope break in the Lunnan—Gucheng area; and Middle-Lower Ordovician carbonate interlayer karsts inside the platform.

2. Discovery of Gucheng-6 gas reservoir

2.1. Overview of the discovery

Located in the Gucheng lower uplift inside the Northern Depression, structure Gucheng-6 is geographically in Qiemo county, Bayingolin Mongol Autonomous Prefecture, Xinjiang, about 82 km away from the Qiemo county town. Spud in on July 13th, 2011, and completed on April 26th, 2012, Well Gucheng 6 completed at Ordovician Yingshan Fm. with a total depth of 6169 m.

Mud logging shows that all oil and gas shows in Well Gucheng 6 are concentrated in Ordovician, totally 71 m/7 layers (Fig. 2-a). The max TG is up to 70.31%; 40%—70% gas bubbles is in fish egg shape on the mud ditch surface, with no oil spots; after throttled and circulated, the oil and gas was ignited with an orange flame as high as 1—8 m.

On May 15th, 2012, Well Gucheng 6 tested oil at 6144—6169 m of Ying-3 member, the Ordovician Yinshan Formation, and got a gas production of \( 26.423 \times 10^4 \) m³/d with 8 mm choke at the oil pressure of 30.4 MPa, and the interval was confirmed as a gas layer by testing; the testing curve shows that the oil pressure is stable, indicating sufficient formation fluid delivery (Fig. 2-b).

2.2. Geologic characteristics of the gas reservoir

2.2.1. Formation and pays

The formations revealed by Well Gucheng 6 include Cenozoic Quaternary, Neogene, Paleogene; Mesozoic Cretaceous, Triassic; Paleozoic Carboniferous, Ordovician (non-penetrated) from the top to the bottom; and the Mesozoic Jurassic, Paleozoic Permian, Devonian and Silurian are absent. The drilling results indicate that there are three large unconformities in the Gucheng area: Carboniferous/Ordovician unconformity; Triassic/Carboniferous unconformity; Cretaceous/Triassic unconformity.

Fig. 2. Composite exploration diagram of Well Gucheng 6.
The major pay in Well Gucheng 6 is Ying-3 member of the Ordovician Yinshan Fm. (Fig. 2-a), which is characterized by bead-shape strong reflection on the seismic profile (Fig. 2-c), and the lithology mainly includes limestone, dolomite-bearing limestone and dolomitic limestone. The logging data interpreted 80.5 m/8 gas layers, among which 31 m/3 layers are type II reservoirs and 49.5 m/5 layers are type III. The reservoir can be roughly divided into two segments: the upper interval from 6072.0 to 6089.0 m, 17.0 m thick, is type II reservoir with a porosity of 3.7%, in which fractures were revealed by electronic imaging logging; the lower interval from 6144.0 to 6158.0 m, 14.0 m thick, is fracture-vuggy type II reservoir with a porosity of 2.5%–3.6%. The dolomite content in the pay zone of Well Gucheng 6 is well correlated with reservoir physical property, which directly indicates that reservoir development is related to dolomite content.

2.2.2. Gas reservoir properties

Chemical analysis results show that Gucheng-6 gas reservoir is a dry gas reservoir, and the gas produced there has a relative density of 0.614–0.627, and relative molecular mass of 19.71. The gas has a CH₄ content of 89.6%–91.4%, CO₂ content of 4.4%–5.37%, N₂ content of 3.91%–4.72%, hydrocarbon heavier than C₂H₆ of less than 1%, and aridity coefficient of 0.998; the PVT phase diagram shows the fluid is dry gas.

The temperature in the Gucheng-6 gas layer is 170.3 °C, discounted to the geothermal gradient of 2.79 °C/100 m, which is normal low temperature system in the Gucheng area; the formation pressure is 70.55 MPa, with a pressure coefficient of 1.18, representing normal pressure system.

3. Exploration history

3.1. Hardships in the exploration of marine clastic rocks

From 1995 to 2003, the exploration in the Gucheng lower uplift and its periphery mainly focused on the marine clastic rocks, and the major targets were the stratigraphic—lithologic traps, including: Donghe sandstone estuarine lithologic traps; Silurian overlap lithologic traps; Upper Ordovician slope-shelf turbidites.

1) Three wells were drilled on the Donghe sandstone of marine bay facies. In 1995, Well Tazhong 28 and Tazhong 29 failed because there was no Donghe sandstone and “ancient gulf” and Carboniferous sandstone stratigraphic—lithologic traps at the well location, and the Donghe sandstone pinched out in the north; in 2003, in search of Donghe sandstone lithologic traps in bay facies further north, and Well Tazhong 51 was drilled and failed again due to the missing of Donghe sandstones. Following the same thinking, in 1996 ESSO drilled Well Qiebei 1 at the south margin of neighboring Manjiaer sag, although 75 m thick Donghe sandstone was revealed, the well still failed because of trap uncertainty.

2) Four wells were deployed targeting at Silurian overlap lithologic traps. In 1995, Well Tazhong 32 and Tazhong 33 were drilled simultaneously, mainly targeting at Silurian asphalt sandstone; 245 m thick Silurian was revealed by Well Tazhong 32, and 431 m Silurian by Tazhong 33. Well Tazhong 32 discovered 2 layers with oil shows in the Silurian, and sampled fluorescent cuttings of 3 m and oil-bearing core 1.1 m, midway testing with MFE tool didn’t get oil and gas, thus the layer was concluded as dry; Well Tazhong 33 also detected weak gas shows and fluorescent shows in the Silurian asphalt sandstone. The post-drilling evaluation suggests that the asphalt sandstone is below the oil—water contact of Silurian overlap lithologic trap, and there may develop overlap lithologic trap reservoirs at the structural high of the overlap stratigraphic trap further south. Under the direction of this thinking, Well Tazhong 34 was drilled in 1996, which revealed 203 m thick Silurian, but no oil shows; analysis shows that the poor lateral sealing of the fault causes the invalidity of the traps. In 2003, in search for Silurian asphalt sandstone overlap lithologic traps, Well Mannan 1 was drilled at the south margin of the neighboring Manjiaer sag, revealing 300 m thick Silurian but no oil and gas shows, and well testing obtained a water production of 15.04 m³/d; post-drilling analysis shows that although the Silurian reservoir has good physical property, without qualified seal, the Silurian overlap stratigraphic trap fails to form effective closure.

3) The Upper Ordovician slope-shelf turbidite shown as abnormal reflection or inner strong reflection, used to be the secondary exploration target for many wells. From 1995 to 2003, the drilling data of five wells (Tazhong 28, Tazhong 29, Tazhong 32, Tazhong 33 and Mannan 1) suggests that the inner strong reflection anomaly is turbidite except Well Tazhong 33 where the Upper Ordovician inner strong reflection anomaly is basalt. In 2006, the Upper Ordovician inner reflection anomaly was found in Well Manjia 1 and considered to be turbidite, thus the Well Manjia 1 was drilled (Fig. 3), however, the drilling results show that the Upper Ordovician inner abnormal and strong reflection correspond to argillaceous mudstone. Although some wells encountered Ordovician carbonate rocks, there was no breakthrough.

![Fig. 3. Seismic cross-section of Well Manjia 1.](image)
3.2. Dawn of hydrocarbon discovery after encountering the reef in Gucheng slope break

The discovery of reef condensate gas field [1–3] in the Upper Ordovician Lianlitage Fm. by Well Tazhong 62 prompted a major change in exploration thinking of the Gucheng lower uplift; the Gucheng area probably had the sedimentary environment and geologic conditions for growth of platform margin, hence the exploration shifted from the marine clastic rock to the deep Ordovician platform margin.

3.2.1. Confirmation of Lunnan—Gucheng slope break

Inspired by the discovery of the platform margin reef condensate gas fields in the upper Ordovician Lianlitage Fm., the Cambrian—Ordovician lithofacies paleogeography research was carried out across the Tarim platform from 2004 to 2005, obtaining important findings in two aspects.

1) In the Cambrian—early Ordovician, the structure background across Tadong area is passive continental margin depression (aulacogen). The west of the aulacogen is Lunnan—Gucheng platform margin where mounded foreset reflection representing platform margin can be observed in Cambrian—Lower Ordovician, and the east of the aulacogen is Luoxi platform margin.

2) The depositional background of “large platform and two slopes” is confirmed in the Cambrian—Lower Ordovician across the Tarim Basin (Fig. 4). During the depositional stage of Cambrian—Lower Ordovician, the Tarim Basin can be divided into west platform, east basin and Luoxi platform. The west platform is bounded to the east basin by Lunnan—Gucheng platform margin, while the east basin borders the Luoxi platform by Luoxi platform margin. From the Lunnan—Gucheng slope to the west there is a large carbonate platform called the west platform. In the Gucheng slope break, there may develop reef bodies in Ordovician.

3.2.2. Re-division of structure unit to underline the exploration potential in the Gucheng area

Based on 19 seismic profiles acquired in 1983 across the basin, the Tarim Basin is divided into the structural framework of “three uplifts and four depressions”, the secondary unit Gucheng lower uplift is at the west tip of southeast uplift [4]. Based on the understanding about the Lunnan—Gucheng Cambrian—Upper Ordovician slope break, following the approach that the Lower Paleozoic carbonate rock is the major exploration target, the Gucheng lower uplift is dissected from the southeast uplift as the second step of Tazhong uplift connecting with the Tazhong uplift as a whole, in this way, the geologic evaluation class of the Gucheng lower uplift was raised.

1) Near oil generation sag, the Gucheng lower uplift and its periphery have good hydrocarbon source conditions. The Gucheng lower uplift joins the Manjiaer sag in the east where a set of thick deep water shelf source rocks developed in the Cambrian—Middle Lower Ordovician, and the source rocks are mainly composed of argillaceous rocks, limestones and transitional rocks between them, with a thickness from 50 m to 360 m. Geochemical indices, such as organic carbon abundance, hydrocarbon potential, chloroform bitumen “A” and total hydrocarbon content show that all the source rocks in Manjiaer sag are up to or above the standard of “good oil generation rock” [5–7].

2) There are many sets of Lower Paleozoic carbonate reservoirs in the Gucheng lower uplift. Inspired by the exploration achievements in the Tazhong uplift, there may develop several sets of reef reservoirs and lower Ordovician inner reservoirs in the Gucheng lower uplift.

3) The Lower Paleozoic carbonate rocks in the Gucheng lower uplift have better oil and gas preservation conditions than those in Tazhong. There developed an Upper Paleozoic regional seal in Gucheng area, Querquek Fm. Mudstone is about 1000–1800 m thick in wide distribution, which can effectively prevent the escape of the lower oil gas, providing sealing for the preservation of Lower Paleozoic carbonate reservoir.

3.2.3. Good hydrocarbon shows in Well Gucheng 4 in the Gucheng slope break

The exploration in the Gucheng slope break can be divided into two stages: the first stage is from 2003 to 2004, during which Well Gucheng 2 and Gucheng 3 were drilled; the second stage is in 2005, during which Well Gucheng 4 was drilled.

Well Gucheng 2 and Gucheng 3 targeting the lower Ordovician carbonate rocks were drilled in search of Lower Ordovician primary oil reservoirs and the oiliness of Tadong Cambrian—Lower Ordovician slope break. The drilling results suggest there are “structures but no traps” in the area. Although the drilling of Well Gucheng 2 and Gucheng 3 failed, it gave us the inspiration of “seeking good targets in the north flat area”.

In 2004, in accordance to the thinking of “seeking favorable reservoir-seal assemblages at the platform margin, approaching source rocks and keeping away from the Cherchen complex fault zone”, PetroChina Tarim Oilfield Company strengthened the seismic survey at the Gucheng platform margin and deployed 2D 1000 km/15 lines. The newly-deployed survey lines basically control the structural high at the Gucheng platform margin, the new survey lines and old data of good quality were used to finely delineate the mounded reflection at the platform margin, and outline the reef.
distribution and confirm the drilling targets, afterwards Well Gucheng 4 was deployed. With the Lower Ordovician-Upper Cambrian as the target, Well Gucheng 4 aimed to figure out the lithology, physical property and oiliness of the Gucheng slope break, and promote the petroleum exploration and evaluation in the Lower Paleozoic high energy belt across the Tarim basin. Well Gucheng 4, completed drilling on December 19th, 2006, and had gas shows at 119 m/6 layers; testing results are: 5564—5595 m, completion testing obtained a gas production of 24 m³/d after swabbing, confirming that it is oil-bearing; 5778—5786 m, completion testing obtained a fluid production of 3.5 m³/d, confirming that it is a dry layer; and 6416.77—6550.0 m, midway testing produced 11.57 m³/d of water, so it is a water layer.

Although Well Gucheng 4 failed, its post-drilling evaluation has far-reaching significance to the exploration of the deep formations in the Gucheng lower uplift: (1) it confirmed the existence of Gucheng platform margin. The Middle-Lower Ordovician developed typical medium-low energy sandy reef and lime mounds at the gentle slope of the platform margin, while the Upper Cambrian developed slump deposits at the upper slope of the platform margin; (2) it revealed the Lower Paleozoic qualified reservoir, with the logging data interpreting 38.5 m thick type I reservoir, 18 m thick type II, and 45.5 m thick type III; (3) it revealed many series of asphalt layers, especially breccia asphalt in the Cambrian dolomite interval with high thermal evolution degree (R0 of more than 3.0%), indicating there was an ancient oil reservoir but was destroyed by thermal effect; (4) it also revealed that the gas shows were found in 119 m/6 layers, and the testing in Middle Ordovician tapped a low gas flow, indicating there was a late gas accumulation in this area.

3.3. Persistent technical research for over 3 years resulted in the confirmation of drilling targets and major exploration breakthroughs finally

The change in geologic understanding led to the shift of the major exploration domain to the Lower Paleozoic carbonate rocks, and the major target formation is the lower Ordovician interlayer karst reservoir. However, how to confirm the exploration target and make breakthrough in one fell swoop? The key is to lock prospects and select favorable target points. The exploration success of carbonate rocks in Tabei and Tazhong shows that reservoir prediction is the key, and seismic technology research is the safeguard. Therefore, PetroChina Tarim Oilfield Company carried out major research on tricky issues in seismic survey for 3 years, in-depth research and scientific deployment finally brought about the major breakthrough in the Gucheng-6 Ordovician in 2012.

3.3.1. Wide-line array and non-seismic research in the desert hinterland

In 2008, the wide-line seismic survey was firstly conducted in the desert hinterland at the platform, totally 2 lines 147 km long, one is the well-tie section from Well Gucheng 1 to Well Gucheng 4, the other a nearly S—N trending section across structure Gucheng-6. The wide-line survey has two purposes: finding the seismic basis of interlayer karst reservoirs; reducing the 3D seismic deployment risk. The implementation results show that wide lines are very effective, which is shown as the significant improvement in data quality and equivalent horizon of hydrocarbon shows in Gucheng-4 and paleo-high area (Fig. 5), which greatly enhanced the geologic understanding and provided basis for 3D seismic deployment.

The experience shows that because the carbonate reservoir has strong heterogeneity, the wide line seismic data can show the lateral formation distribution but can’t address the problem of reservoir prediction, only 3D seismic data can meet the demand of cavity description and reservoir prediction. Under the circumstance of no commercial wells, there is a new issue of whether and how a 3D seismic survey of exploration can be deployed. Through research and demonstration from multiple aspects, non-seismic high-precision field-building was introduced. In 2008, 8 high-precision continuous electromagnetic profiles of 388 km long in total were deployed in the Gucheng-6 structure, which showed laminar feature of hydrocarbon and local enrichment near the top of Lower Ordovician—Cambrian (Fig. 6), among which the hydrocarbon shows are most favorable in the Gucheng-6 structure. On the basis of 2D wide-line and continuous electromagnetic data, the deployment work area of 3D was further clarified.

3.3.2. 3D seismic survey in advance, breaking conventions

In 2009, PetroChina Exploration & Production Company and Tarim Oilfield Company made a decision to break the convention and conduct 3D seismic survey with folded coverage of 170.2 km² first with mineral right protection fund under the circumstance of no commercial wells. The 3D seismic data has much better quality in inner imaging, providing an important guarantee for the prediction of carbonate heterogeneous reservoirs.

3.3.3. Gucheng major breakthrough of the interlayer karst reservoir

In the thick inner carbonate rock in the Ordovician of Tazhong area, a large condensate gas reservoir was discovered.

![Fig. 5. Comparison between wide line and conventional 2D sections.](image)
Previous study shows there is an unconformity in the thick inner carbonate rock, along which developed fracture-vuggy karst reservoirs [8] in quasi-layer and heterogeneous distribution, thus the theory of interlayer karst was put forward to direct the discovery of Halahatang oil-gas field [9].

The interlayer karst theory provides theoretical basis for the carbonate rock exploration in the Tarim Basin, and also broadens the thinking of Ordovician carbonate rock exploration in the Gucheng area. The Gucheng lower uplift and the Tazhong uplift are connected as a whole in structure, where the Cambrian—Lower Ordovician are carbonate platform facies with similar depositional and structural background, and interlayer karst reservoirs might develop universally (Fig. 7).

Fine examination of the Gucheng 3D seismic data shows there are two sets of laminar and heterogeneous karst reservoirs in the 3D work area, one on the top of the lower Ordovician Yingshan Fm. is shown as flaky strong reflection on the seismic profile, and the other in the Middle-Lower Yingshan Fm. features bead-shape strong reflection (Fig. 8).

From 2005 to 2007, Well Gulong 1 drilled by Sinopec in the west part of the Gucheng lower uplift encountered the dolomite reservoir in Ying-3 member of the Ordovician Yingshan Fm. and tested an oil production of $1.0067 \times 10^4$ m$^3$/d [10]. Drilling data shows that the qualified dolomite reservoir is the combined result of interlayer karstification and thermal fluid reformation [11], further indicating the Middle-Lower Ordovician reservoir is controlled by interlayer karstification in the Gucheng area.

In July, 2011, with the interlayer karst reservoir in the lower Ordovician Yingshan Fm. as the target, Well Gucheng 6 was drilled. The geologic study while drilling shows that: the Yingshan Fm. reservoir space revealed by Well Gucheng 6 includes intergranular pores, intercrystalline pores and acicular dissolved pores, which shows the feature of relatively homogeneous small dissolved pores on imaging logging, and vadose silt filling the pore can be observed at the depth of 6160 m. Lost circulation happened at the drilling depth of 6162 m, and the lost drilling fluid was about 14.8 m$^3$, and the well was finished ahead of schedule due to the hydrocarbon discovery at the top of the dissolved cave. These geologic features prove that there are fracture-cave interlayer karst reservoirs in Gucheng area and bring about the major breakthrough of natural gas exploration in Well Gucheng 6.
4. Exploration prospect and enlightenment

4.1. Exploration prospect

The Lower Paleozoic carbonate rock in Gucheng area has good source-reservoir-seal assemblage, and favorable palaeostructural background, indicating excellent petroleum geologic conditions. The Middle-Lower Ordovician developed rich interlayer karst, which makes up good reservoir-seal assemblage with the overlying Ordovician Querquek Fm. thick mudstone; the Gucheng area lies on the slope high of long-term inherited palaeo-uplift since Caledonian period and in the favorable distribution region of basin facies qualified source rock in the Cambrian-Lower Middle Ordovician, which could trap early oil and gas and later pyrolysis gas. The breakthrough of Well Gucheng 6 has verified the exploration potential of the area, which is another carbonate exploration domain after Tazhong and Tabei. The exploration coverage at the burial depth of 7000 m (altitude 6000 m) in the Lower Paleozoic carbonate rock in the Gucheng area is about 1.2 x 10^4 km², showing a broad exploration prospect (Fig. 9).

The breakthrough in the deep dolomite of the Ordovician Yingshan Fm. in Well Gucheng 6 pointed a new direction for the exploration in the dolomite domain in the Lower Paleozoic in the Tarim Basin. Regional analysis shows that during the depositional stage of the Lower Ordovician Yingshan Fm., the west platform was a unified whole where large scale dolomite reservoirs developed in the Lower Yingshan Fm. throughout the area, moreover, the Tazhong uplift, Manxi low ridge and Tabei uplift unified in the range of 8000 m trap contour, possibly containing oil gas as a whole. The Lower Ordovician lower Yingshan Fm. dolomite distributes stably in Tabei, Tazhong uplift and Hetian paleo-uplift, and the exploration coverage of the three uplifts and their periphery with the burial depth of less than 7000 m is about 13.6 x 10^4 km², showing huge exploration potential.

4.2. Exploration enlightenments from Gucheng-6 gas field

The major breakthrough of Well Gucheng 6 brought about important enlightenments on exploration.

1) New geologic understanding is the prerequisite of exploration discovery. The breakthrough in geologic understanding led to the transformation of exploration thinking, and brought about the shift of exploration target from marine clastic rocks to the platform margin reefs and then to the intra-platform interlayer karsts.

2) 3D seismic survey and addressing bottleneck in seismic technology is an important guarantee for the breakthrough. For the exploration of carbonate rocks with strong heterogeneity, 3D seismic survey is the core factor for the accurate reservoir prediction and the fundamental data for the exploration discovery in the heterogeneous reservoir; based on this recognition, 3D seismic survey was deployed in advance by breaking the conventional procedure, and the clear identification of fracture-cave reservoirs through 3D data is the key to the final discovery of Gucheng-6 gas field and the major breakthrough.

3) Persistent exploration is the key to realize the breakthrough in the new exploration zone [12]. Realizing that any misunderstanding in recognition means the miss of chance of finding another new exploration zone; only by emancipation of mind and persistent research and practice can the recognition be deepened, the theory innovated and breakthrough made in the end.

References


