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Accumulation characteristics of CO₂-bearing natural gas reservoir in Xudong area of Xujiaweizi fault depression

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Abstract: In the north of Songliao basin, some high CO₂ gas reservoirs have been found while great breakthroughs have been made in hydrocarbon natural gas. Based on the analysis of the reservoir characteristics of CO₂ gas reservoirs in Xudong area, this paper clarifies that the Yingcheng formation CO₂ is inorganic gas, volcanic rock is the main reservoir, and establishes the differential accumulation model of CO₂ gas reservoirs in the study area, which can also guide further research and exploration.

1. Stratigraphic characteristics

Xudong area is located in the eastern slope of Xujiaweizi fault depression in the north of Songliao basin, with NW-SE spreading to the north, from Songzhan to Chaoyanggou in the south, with a length of 50km in the north and a width of 15km in the east and west, with an area of about 1040km². Xudong slope as a whole to NNW direction of the west slope, average slope of 3 °, locally developed micro amplitude nose-like structure; The genetic types of natural gas in this area are very complex, including organic and inorganic genetic natural gas. CO₂ gas reservoirs have been found in volcanic rocks of Yingcheng formation [1]. These discoveries have opened up a new field in the search for non-hydrocarbon gas reservoirs.

Drilling in the area reveals that the Xudong slope has well-developed strata, including middle Jurassic Huoshiling formation, lower cretaceous Shahezi formation, Yingcheng formation, Denglouku formation and Quantou formation from bottom to top. The main gas bearing strata are the sand conglomerate of Denglouku formation and volcanic gas layer of Yingcheng formation.

The basement of the study area is metamorphic rock such as mudstone, phyllite and intrusive rock such as granite. The Huoshiling formation was formed in the early stage of the faulted basin, with a set of clastic rocks at the bottom, volcanic rocks at the middle and upper parts, and shore-shallow lacustrine deposits during the intermittent eruption.

The lower cretaceous Shahezi formation, which was the main source rock and local cap rock, was deposited at the peak of the development of the fault depression basin and generally developed in the depression. The lithology is mainly dark mudstone with argillaceous sandstone and conglomerate.

During the sedimentary period of Yingcheng formation, basement faults were active frequently and volcanic activities were intense. The third section of Yingcheng formation is a grayish-white, rhyolitic breccia, rhyolite, tuff, andesite, andesic breccia, andesic basalt, basaltic andesite and basalt with a thickness of 200-700m and developed in Shengping, Songzhan uplift and Anda subdepression.

During the sedimentary period of the first and second member of Quantou formation, it was a stable depression stage, mainly composed of argillaceous siltstone and siltstone intercalated with dark purple mudstone of littoral and shallow lake and fluvial facies, with a total thickness of 300m ~ 500m,



a stable distribution, and a good sealing ability, forming a regional cap layer of deep natural gas reservoir.

2. Genetic type of CO₂

The natural gas of Yingcheng formation in well s28 contains 89.82% carbon dioxide and 9.25% methane, and -7.08 ~ -7.3‰ carbon isotope. According to the carbon dioxide gas genetic type plate [2], it's inorganic carbon dioxide gas (figure 1).

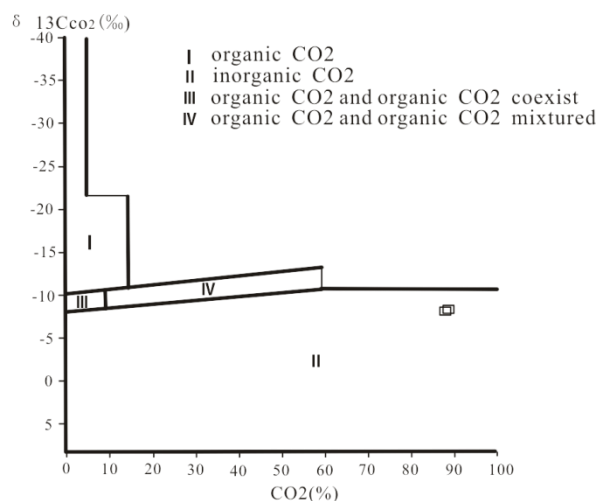


Figure 1 Identification of organic and inorganic CO₂

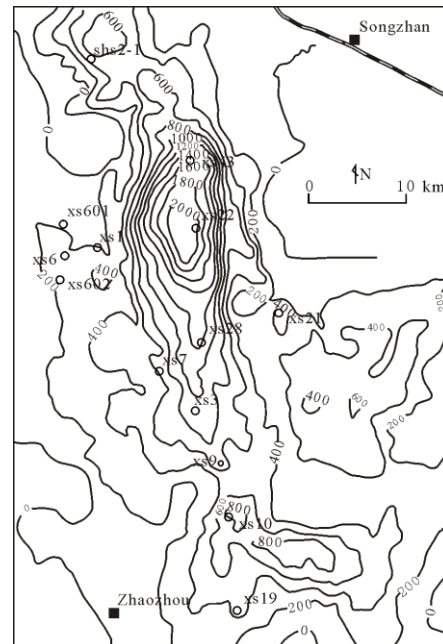


Figure 2 Isopach map of volcanic rocks of Yingcheng formation in Xujiaweizi area

3. Reservoir rock characteristics

3.1 reservoir lithologic characteristics

The distribution of volcanic rocks in Yingcheng formation of Xujiaweizi depression is obviously different from north to south. The reservoir in xs28 well with high CO₂ content is mainly rhyolite with corrosion pores.

3.2 reservoir distribution characteristics

In Xujiaweizi depression, the Yingcheng formation volcanic rocks, are widely distributed. The thickness is large in the deep part of the structure east of Xuzhong fault, and the maximum thickness is located in the xs22 well area, which can reach more than 2400m, generally 100-900m. The thickness distribution of volcanic rocks shows obvious lateral mutation, and the larger thickness is generally at the local tectonic high point (figure2).

4. Gas reservoir characteristics

Well xs28 is located in the western structural low position of Xuzhong fault in the central Xujiaweizi depression. The gas bearing layer is thick and the gas bottom exceeds the overflow point of the structural trap. The reservoir lithology is rhyolite with good physical properties, and it is a typical structure-lithologic gas reservoir [3]. Volcanic rock reservoir is characterized by strong heterogeneity, quick lateral change, poor connectivity and discontinuity. The heterogeneity of lithology leads to poor

gas-water differentiation, and lithology is the main controlling factor of volcanic gas reservoir formation, both hydrocarbon gas and non-hydrocarbon gas.

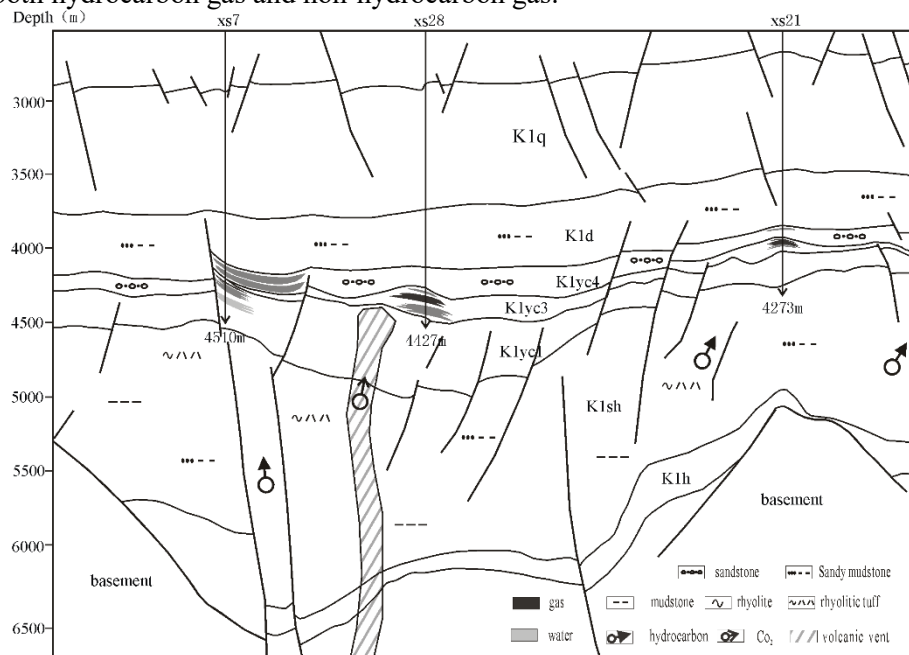


Figure 3 accumulation mode of well xs28

Xujiaweizi depression exist both hydrocarbon gas and CO₂ reservoirs, they share the same conditions for accumulation. But CO₂ gas was found only in few wells. It is sure that migration pathway, deep fracture or volcanic vent, is one of the most important necessary conditions for CO₂ Accumulation. And trap is another important condition [4]. From the cross-well profile of well xs7-xs28- xs22 (figure3), CO₂ comes from deep site, but not enough to fill the whole trap, it can only form gas reservoir at the top of the trap. The filling time of carbon dioxide was later than that of hydrocarbon gas in Songliao basin [5]. CO₂ cannot displace the hydrocarbon gas in the existing hydrocarbon gas reservoir to form CO₂ gas reservoir. Only when the hydrocarbon was not enough to fill the trap, the CO₂ gas filled the rest of the trap, CO₂ and hydrocarbon gas can be found in the same trap.

5. Conclusion

The CO₂ gas in xudong was inorganic and came from the upper mantle. The distribution of CO₂ in yingcheng formation was controlled by basement faults. Basement faults and magmatic channel is the main channels for co2 migration, Yingcheng formation volcanic reservoir and dunlouku formation mudstone constitute favorable reservoir - cap combination.CO₂ accumulation period was later than the stages of the hydrocarbon gases. CO₂ gas reservoirs are distributed in traps close to basement faults but far away from source rocks. CO₂ gas reservoir in Xudong belongs to differential accumulation reservoir.

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