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The Study on the Characteristics and Evolution of Shale Gas Reservoir of the Jurassic in Qaidam Basin

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1 Introduction

Since the successful development of shale gas reservoir in our country southern marine stratigraphy, it has attracted more and more attention to shale oil and gas in Qaidam Basin. The research of Jurassic shale gas in the Qaidam Basin mainly has the following problems: It is low exploration in North Qaidam Basin, Drilling sparse, the distribution of Jurassic gas bearing shale is not clear; The study area wells coring analysis and test data is sparse, the characteristics of Jurassic shale gas reservoir hasn't been studied; And as shale gas reservoir, we are not clear its resource potential. For the above three questions, This study firstly analyzes the results of previous studies, the distribution of Jurassic shale gas reservoir was determined according to the distribution of the sedimentary facies and strata distribution, and then through system sampling, core observation, petrographic thin section observation, identification by scanning electron microscope and electron probe, geochemical experiment, X ray diffraction analysis and gas testing etc, study on the characteristics and gas bearing of shale gas reservoir. Finally, based on the above research, evaluating the shale gas reservoir and select the favourable area

The Jurassic system of the Qaidam Basin is Huxishan Formation, Xiaomeigou Formation, Dameigou Formation, Caishiling Formation and Hongshuigou Formation. We combine well logging data and previous studies, found that the shale gas reservoir mainly developed in the lower Jurassic Huxishan Formation and middle Jurassic Dameigou Formation, thus this research focuses the research on Huxishan Formation and Dameigou Formation. During*

Early Jurassic Qaidam Basin is a fault basin, the middle Jurassic sedimentary center migrated east, expansion of

sedimentary range, until the late Jurassic end deposits. This study firstly establishes the sequence stratigraphic framework, divided the Jurassic system into 14 III sequence, and 3 II sequence, and then take stratigraphic correlation in stratigraphic framework. Outcrop stratigraphic correlation shows that, the lower Jurassic Huxishan Formation distributed in Lenghu area and Hutongnuoer uplift belt outcrops, and the two can be compared. The Xiaomeigou Formation is a series of terrestrial coal bearing system, only in small areas of outcrop and Lenghu area. The Dameigou Formation On the basis of the lower Jurassic, the middle Jurassic distributed in Nanbaxian and Mahai north area, and the complete outcrop seen in the Dachaidan areas. The whole Dameigou Formation parted in three, the lower part is clastic rock stratum, the middle is coal bearing system, and the upper is carbonaceous shale and oil shale rock. From the bottom of the formation to the highest, the strata are growing more and more complete. From these field profiles, Lvcaoshan profile has the maximum deposition thickness, and the Baishushan profile has the minimum deposition thickness. The well comparison shows that, the lower Jurassic Huxishan Formation distributed in Lenghu area, and well Lengke-1 thickness is the biggest, and gradually thinning around, In Yiliping area although there is no drilling reveal the middle Jurassic strata, but according to the development of dark mud shale in the Lenghu area, combined with sedimentary facies and seismic analysis predicted in Yiliping depression development thick Huxishan Formation dark mudstone and shale. The middle Jurassic Dameigou Formation shale gas reservoir develop in Dameigou Formation (five section J2d5 and seven section J2d7), five section is shale gas section, seven section is shale oil section, sedimentary facies analysis is shallow lake deposit, mainly distributed

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in Suganhu depression, Yuka fault depression, Hongshan fault depression-Ounan depression and Delingha area (seismic data forecast).

2 Sedimentary Environment

The sedimentary environment of the Dameigou deposit was analyzed by the trace element analysis, result shows that, the dark mudstone of Dameigou Formation $V/Cr < 2.00$, $Ni/Co < 5.00$, $U/Th < 0.75$, according to the principle and the corresponding criterion of the redox environment, estimate the Dameigou Formation is mainly developed in oxidation– weak reduction environment, illustrate the water is not deep enough, and is shallow lake deposit. Mentime the analysis of trace elements ($Sr/Ba < 1$, $Sr/Cu < 10$) shows that, it is warm humid climate and fresh water deposition environment.

3 Reservoir Characteristic

Reservoir characteristic analysis shows that, The shale reservoir development of many kinds of rock types combination in the research area, mineral composition analysis showed that, the Dameigou formation of mineral composition of shale gas reservoirs has the characteristic of "two high and one low", the mineral elements are mainly clay ($>50\%$), second is the brittle minerals (quartz+ feldspar+ pyrite), the carbonate minerals is rare (Fig.1).

Compare with other areas shale reservoir of home and abroad, T The content of clay minerals is high and the content of brittle minerals is low, the content of clay minerals is high and the content of brittle minerals is low; Longitudinally, it has high content of brittle minerals in the top and bottom of Dameigou Formation and high content of clay in the middle Dameigou Formation (Table 1).

The research of brittle curve shows that, reservoir brittleness is mainly controlled by lithology, the higher the sandy content in reservoir rocks, the more brittle the reservoir rocks are, and the carbon content is higher, the greater of the brittle value. And the shale gas reservoir has

many types of pores, containing primary pore, intercrystalline pore of clay minerals, pores related to organic matter and micro cracks, etc. In the reservoir space, the fracture size distribution is the biggest (200nm–6um), pores related to organic matter is the smallest (300nm–740nm), primary pore and intercrystalline pore distributed between the above, and the most developing is intergranular pore, the intergranular pores include the intergranular pores of the clay minerals and the intergranular pores of the pyrite, main is clay intergranular, the clay minerals main are illite smectite and kaolinite, and the illite smectite intergranular pores distributed in 300nm–2un, the kaolinite intergranular pores distributed in 200nm–700nm, Nanometer scale porosity is the main pore in the reservoir space of the research area, total porosity of 70%. The porosity of shale gas reservoir is controlled by lithology, overall, the porosity value is: the sandy mudstone>the oil shale>the mudstone>the carbonaceous mudstone. Longitudinally, the porosity increases with the decrease of the depth of the buried depth and the increases with the increase of the depth of the buried depth, the research shows that the upper porosity decreases with the increase of the depth which is caused by mechanical compaction, the porosity of the part increases with the increase of the depth of the buried depth which is caused by the transformation of hydrocarbon and clay minerals. In fact, the Dameigou Formation reservoir porosity is very bad, which may have two reasons, The one is that the maturity of Jurassic

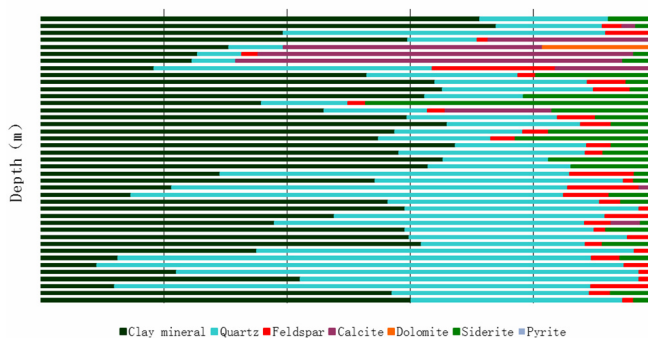


Fig. 1. Total rock mineral analysis and statistics of the Dameigou Formation in Well Chaiye-1 Qaidam Basin.

Table1 the main mineral composition of shale, at home and abroad

Country	Shale	Clay content (%)	Quartz content (%)
American	Fort Worth Basin, Mississippian, Barnett Formation	<50	30–50
	Appalachian Basin, Devonian, Ohio Formation	20–80	45–60
	Michigan Basin, Devonian, Antrim Formation	—	20–41
	Illinois Basin, Devonian, New Albany Formation	10–20	50
	San Juan Basin, Cretaceous, Lewis Formation	13–23	50–75
China	Sichuan Basin, Cambrian, Qiongzhusi Formation	15.3–56.1	28–56
	Sichuan Basin, Cambrian, Longmaxi Formation	12.7–51.5	24–44
	Erdos Basin, Triassic, Yanchang Formation	10–60	2–7
	Qaidam Basin, Jurassic, Dameigou Formation	30–90	35.5

outcrop sample in Qaidam Basin is generally low, compaction and later tectonic reconstruction are serious, making the primary porosity of mud shale is poor; the other is outcrop samples weathered by weathering develop secondary porosity, but also suffered debris particles plug or fill. The superposition of two factors caused the poor porosity.

4 Organic Geochemical

Organic geochemical analysis showed that, it has high abundance of organic matter of the target layer in study area. The total organic carbon of Huxishan Formation is between 0.9% to 8.72%, the mean value is 4.56%, the hydrocarbon generating capacity is mainly distributed between 0.11 to 30.5mg/g, the mean value is 35.8mg/g; The total organic carbon of Dameigou Formation is between 4.27% to 20.51%, the mean value is 13.1%, the hydrocarbon generating capacity is mainly distributed between 5.69 to 84.54mg/g, the mean value is 39.36mg/g. The type of organic matter is scattered, the study area of Jurassic in dark shale is the main source of terrigenous organic matter and a small amount of aquatic plants, in macerals, coal, carbonaceous mudstone and mudstone are dominated by vitrinite which from humus, it is well gas source rock. Mud mud group develop a lot in oil shale, is the main oil source. The HI—Tmax analysis shows that, the Huxishan Formation of the lower Jurassic is mainly II2 type organic matter and III type organic matter, the Dameigou Formation organic matter type range from I type organic matter to III type organic matter, the III type organic matter is main, and the II type organic matter content increased significantly, and there some I type organic matters. All in all, the organic matter type of the middle Jurassic dark mudstone and shale is better than the organic matter type of the lower Jurassic dark mudstone and shale. The organic matter maturity of the lower Jurassic is mainly distributed between 0.4% and 1.45%, the average value is 0.77%, which Ro greater than 1% take the total of 18%; and the organic matter maturity of the middle Jurassic is mainly distributed between 0.45% and 0.72%, the average value is 0.67%, which Ro greater than 1% take the total of 7%. On the whole, the organic matter maturity in the lower and middle Jurassic is most in low mature stage.

5 Gas Bearing

The gas bearing of the shale gas reservoir in the study area was analyzed by field analysis and isothermal adsorption simulation, studies shows that, coalfield drilling measured in dark shale containing hydrocarbon

gas; Field analysis shows Dameigou Formation gas content is controlled by the lithology, the gas content of coal is the highest, it is 8.99m³/t, then is the sandstone, it highest is 4.73m³/t, the last is mudstone and carbonaceous mudstone, and the most of them is less than 1m³/t, but some samples test shows the gas content is more than 2m³/t; The isothermal adsorption simulation shows that it has strong gas adsorption capacity of the Dameigou Formation samples, The content of adsorbed gas is mainly distributed between 2.37 to 18.60m³/t, it also controlled by the lithology, the coal gas adsorption capacity is the strongest, and then is the sandstone, the adsorption of carbonaceous mudstone is small, but the most is more than 1m³/t.

6 Discussion and Conclusions

There are many factors affect the gas content of mud shale, the lithology, formation temperature, pressure, total organic matter, quartz content, clay content, maturity and reservoir space feature, etc, all have relationship with mud shale reservoir. In research area shale reservoir was controlled by the total organic carbon content and lithology. The total organic carbon has affected on gas content of the shale reservoir, general with the increase of the total organic carbon content, gas content increased. The lithology is mainly affected on gas content, property and brittleness of the shale gas reservoir, gas bearing property: gas content in coal > gas content in sandstone > gas content in shale; property is the porosity of shale reservoir: general sandstone porosity > oil shale porosity > mudstone porosity > carbonaceous mudstone porosity; brittleness: the higher carbon content or the higher brittle mineral content (quartz + feldspar + pyrite), the higher brittle of the shale gas reservoir.

Finally, based on comprehensive analysis of the shale gas reservoir characteristics, combining with the actual geological data, according to the comprehensive geological conditions of the research area, select the evaluation parameters (gas shale thickness, the buried depth of the shale gas reservoir, the organic matter abundance, the maturity and gas bearing characteristics) of shale reservoir, and then comprehensive analysis these multiple factors, on the basis of the continental shale gas evaluation constituency standard, select the Lenghu structural belt as the favourable area of the lower Jurassic Huxishan Formation shale gas reservoir, the Yuka fault depression, the Hongshan fault depression—Ounan depression as the favourable area of the middle Jurassic Dameigou Formation. All of the studies we had took is guiding for the shale gas exploration in Qaidam Basin.