Research of geological characteristics in Bashijiqike formation of Keshen-2 gas reservoir, Tarim basin, China

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Abstract:

The Keshen-2 gas field, located in the Kelasu structural zone, is an important gas field in the Kuqa depression. At present, the research level of this field is relatively low because only three wells are drilled in this area. Based on the present data and analogy with other well data in the Kela-2 gas field and Dabei gas field, detailed studies were carried out. Keshen-2 gas field is mainly controlled by the Keshen Fault and Kenshen North Fault. The principal gas pay is Cretaceous Bashijiqike Formation that is a set of deep and huge thick sandstone layers deposited in fan delta front (the third member) and braided delta front (the first and second members). The lithology is mainly fine-intermediate-granular, medium-sorting and subrounded-subangular lithic arkose or feldspathic litharenite. The composition maturity is characterized as facies control. The reservoir quality is affected by burial compaction and diagenesis. The average porosity is 6.28-7.1% and the permeability ranges from 0.08 to 4.09mD. Keshen-2 gas field is a high-pressure, low-poroperm and fractured gas reservoir. The reservoir's characters are poor properties, developed fractures, undeveloped interlayers and good connectivity. The study on the reservoir characters has an important value to the later development.

Key word: Keshen2 gas field, Kelasu tectonic zone, geological characters, communication in gas field.

Introduction

Keshen-2 gas field is located in Baicheng County of Akesu Prefecture in Xinjiang Uygur Autonomous Region. It is geologically at the east section of Kelasu structural belt, Kuqa Depression, in the Tarim Basin. As an important production superseding block of Kela-2 gas field, Keshen-2 gas field displays the good prospect of exploration and exploitation. According to the analysis, the geological reserve of the Keshen-2 gas field has passed 100 billion cubic meters.

At present, the main difficulty existed in the research work is the lack of drill wells in the gas-bearing area of 64 square kilometers of Keshen-2 gas field. Only three drill wells had been finished (Keshen2 well, Keshen201 well and Keshen202 well). While on the Kelasu structural belt, there have Kela-2 gas field (North-Eastern Keshen-2 gas field) and Dabei gas filed (Western Keshen-2 gas field) which have abundant research data and Keshen-2 gas field can utilize the analogy methods with the Kela-2 and Dabei gas fields. The location of these three gas fields shows on the Fig.1.

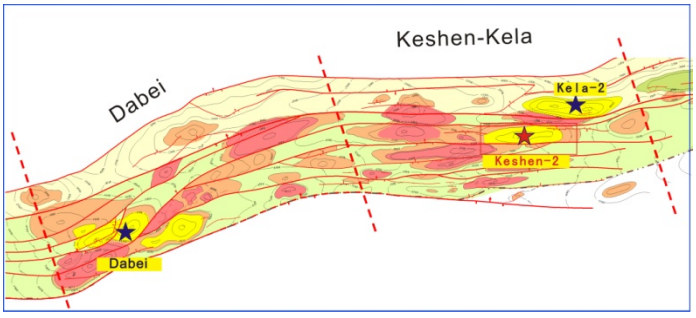


Fig.1 Kelasu structural belt pattern and location of gas fields

Regional structure

Kuqa Depression in the Tarim Basin, in which the Keshen-2 gas field is located, is a foreland basin in the southern Tianshan Mountains structural belt. The depression borders the southern Tianshan Mountains structural belt on the north and Tabei uplift on the south with an east-west length of 550km and a south-north width of 30-80km as well as an area of 28,515km^2.

The Kelasu structural belt is one of the uplifts in the north of the Kuqa Depression and formed in the late period of the Himalayan movement [1-3]. Formation and evolution of this structural belt are mainly under the control of the Dawanqibei-Kelasu faulted belt [4]. The fault system was composed of a series of north dipping thrust faults. These faults occurred in the Jurassic, Cretaceous and vanished in the salt bed in the KM formation of Early Tertiary. The above-salt structure is a kind of propagation fold formed by sliding along the Upper Tertiary sliding-off fault, which inclines generally towards the north. The structure under the salt bed is a complicated anticlinal belt composed of overlapping fault bend folds. The upper part formed the Kela-2 anticline and deeper part shaped the Keshen-2 trap (Fig.2, Fig.3).

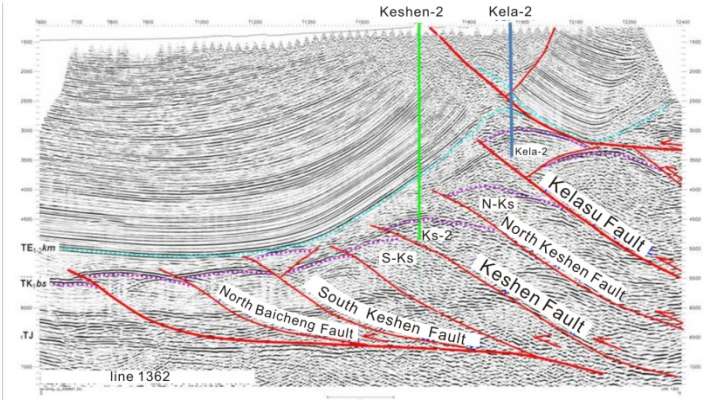


Fig.2 Fault system in Kelasu structural belt

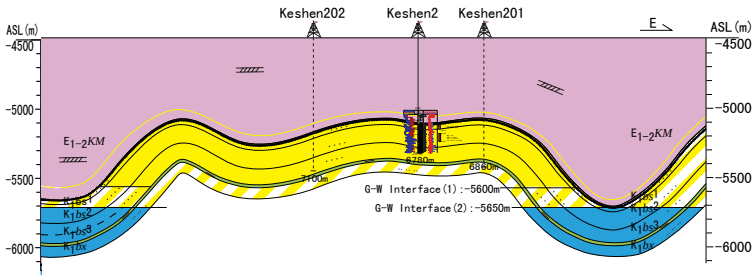


Fig.3 Profile of Keshen-2 gas filed

Strata

The gas-bearing layer is Bashijiqike formation in the Lower Cretaceous where the depth reaches 6000m. Approximately more than 1800m thickness KM strata overlies on the gas-bearing layer. From the upper part to the lower part, the KM strata can be divided into five lithological members in detail: mudstone, gypsiferous salt rock, dolomite, gypsiferous marl and glutenite (Table 1). The giant thickness gypsiferous salt rock and gypsiferous marl are a set of high quality regional seal rock with a

thickness of more than 1500m which is the key factor for the oil and gas abundant in Kuqa front land thrust belt [5-6].

The target strata can be divided into three lithological members. The first member experienced erosion in different lever which had correlation with the depositional background of Kulasu tectonic zone. The thickness of the first member is about 50-70m. The first and the second member have the similar lithology – medium sandstone interbedded with a small amount of mudstone and pelitic siltstone. The second member contained more pure muddy interlayers than the first member and the thickness is about 130-180m. The lithology of the third member is siltstone interbedded with gompholite and the thickness is approximately more than 100m because until now there are no wells which drilled through the third member sequence and it can be estimated based on the information of Dabei and Kela-2 gas field. At present, according the data of drill wells, the thickness of the whole reservoir is above 300 meters which has huge potential for the oil and gas accumulation.

Table 1. Stratigraphy of Keshen-2 gas field

Strata				Code
System	Strata	Formation	Member	
Early Tertiary	Oligocene	Suweiyi		$E_{2-3}s$
	Palaeocene-Eocene	KM	Mudstone	$E_{1-2}KM^1$
			Gypsiferous Salt Rock	$E_{1-2}KM^2$
			Dolomite	$E_{1-2}KM^3$
			Gypsiferous Marl	$E_{1-2}KM^4$
			Glutenite	$E_{1-2}KM^5$
Cretaceous	Lower Cretaceous	Bashijiqike	First	K_1bs^1
			Second	K_1bs^2
			Third	K_1bs^3

Depositional background and sedimentary facies

After Mesozoic, Kuqa area experienced intense thrust-motion from the northern Tianshan orogen and generated foreland basin in the south. The palaeogeographical framework showed mountain in the north and basin in the south which controlled the development of sedimentary facies. In Cretaceous, Tianshan orogen had uplifted and Kuqa area began to form depression so that the geography controlled the direction of the fluid flow. Many exits of provenance occurred in the Tianshan orogen and the clastic sediments deposited in relative fast speed in the Kuqa depression. From the north to the south, the sedimentary facies is alluvial fan, fan delta or braided delta and shore respectively. Alluvial fan, fan delta and braided delta displayed multi-stage overlay in the vertical direction and connected each other in the horizontal direction. These alluvial fans, fan delta and braided delta formed giant sand reservoir which is the main accumulating space for the gas in Keshen-2 gas field.

Bashijiqike formation of Cretaceous, the main target layer of Keshen-2 gas field, is the sedimentation of subfacies as fan delta foreland in the third member of strata and braided delta foreland in the first and second members of strata (Fig.4).

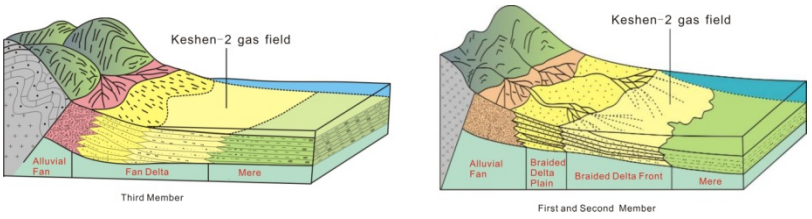


Fig. 4 Sedimentary facies of Bashijiqike formation in Keshen-2 gas filed

Characteristics of reservoir

5.1 Petrology

Based on the analysis of thin sections of Bashijiqike formation in keshen-2 well, the lithology is mainly lithic-feldspar and feldspar-lithic sandstone which characters fine-medium grains with some coarse sand grains and displays medium sorting, poor psephicity and linear contact between particles (Table 2).

Compared with the Kela-2 and Dabei gas filed, Keshen-2 gas field has the similar lithology with Dabei gas field which mainly are lithic-feldspar and feldspar-lithic sandstones while the lithology of Kela-2 gas field is lithic sandstone and feldspar-lithic sandstone (Fig.5). The reason why the compositional maturity in Keshen-2 is lower than Dabei gas field and higher than Kela-2 gas field maybe because the Keshen-2's location is between other two gas fields in the geography and it shows the compositional maturity is controlled by the sedimentary facies.

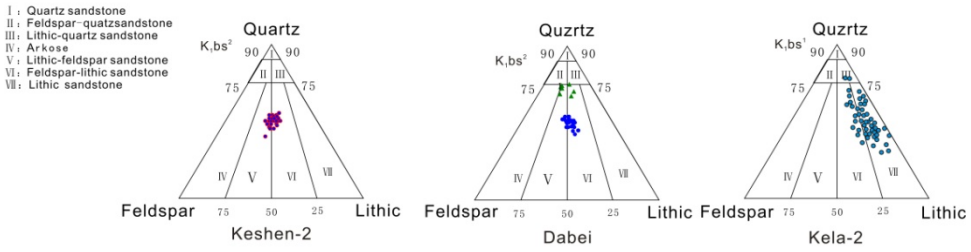


Fig. 5 Types of the reservoir sandstone in three gas fields

Table 2. Component and structure of reservoir rocks in three gas fields

Gas fields	Target Form.	Sample Num.	Component content（%）			Compositional maturity	Grain diameter (mm)	Grading	Contact
			Quartz	Feldspar	Debris	Q/F+R			
Keshen-2	K_1bs^2	14	48.5	24.8	26.7	0.94	0.15-0.35	Med.	linear
	K_1bs^3	10	50	25.1	24.9	1	0.20-0.35	Med.	linear
Kela-2	K_1bs^2	168	41.8	13.2	45	0.72	0.125-0.25	M-G	Linear- dot
	K_1bs^3	178	48.5	15.7	35.8	0.94	0.1-0.30	Good	Linear- dot
Dabei	K1bs2	32	60.04	17.5	25	1.41	0.125-0.5	M-G	Linear- dot
	K1bs3	57	56.3	11.9	33.7	1.23	0.125-0.25	M-G	Linear- dot

5.2 Physical property of reservoir

Physical property of Bashijiqike formation in Keshen-2 gas filed is relatively poor. Two types of properties, cores and log, were counted. By the experiments of cores, the average porosity is 2.99% and the average permeability is 0.031mD. According to the analysis of logs, the average porosity is 5.74% and the average permeability is 0.245mD while the average porosity is 6.85% and the permeability is 0.413mD in the effective reservoir. The effective reservoir is identified by the analogy methods with Dabei gas field because Keshen-2 gas field has the similar depth for the target strata. By comparison with other two gas fields, physical property of the Keshen-2 gas field is similar with the Dabei gas field and has great difference with the Kela-2 gas field (Table 3). The reason is that the burial depth and diagenesis play an import role to the decrease of porosity and permeability.

Tabel 3. Physical property of core and log in three gas fields

Gas fields	Target Form.	Depth （m）	Core				Log			
			Por. （%）		Perm.（mD）		Por. （%）		Perm.（mD）	
			Range	mean	Range	mean	Range	mean	Range	mean
Keshen-2	K1bs	6500-7000	0.6-6.4	2.99	0.007-0.168	0.031	3.6-11.1	5.74	0.02-17.9	0.245
Dabei	K1bs	5300-7000	3.5-9	5.15	0.01-1	0.13	3.5-9	5.69	0.01-1	0.06
Kela-2	K1bs	3500-4000	8.0-20	12.6	0.1-1000	49.4	10-14	12.4	4-150	26.3

5.3 Fractures

Observation from the cores, fractures develop in the Keshen2 gas field. The fractures mainly distribute in the fine-medium sandstones with high angle and calcite filling and the fracture density is 2.37 l/m. From explanation of the imaging log, the fractures display parallel, network and adjoint morphology and the density is 1.06 l/m. The difference of fracture density between cores and imaging log is mainly because it is very hard to identify the micro-fractures in the imaging log. Based on the analysis of three drilling wells, the fractures develop in the east area and fracture strike coincides with the long axis of structures.

5.4 Characteristics of barrier and interlayer

Based on the present research, there has no evidence that effective barrier exist in the Keshen-2 gas field. Kela-2 gas field and Dabei gas field also show that no effective barrier can isolate the gas and formation water. The interlayer can be divided into two types, mud interlayer and sand interlayer. According to the research of three drill wells, the density of mud interlayer is 0.13 and the average thickness of mud interlayer is 0.77m while the sand interlayer are 0.29 and 1.28m, respectively (Table 4). In general, the interlayers in Keshen-2 gas field do not develop and it hard to isolate the gas in the whole reservoir.

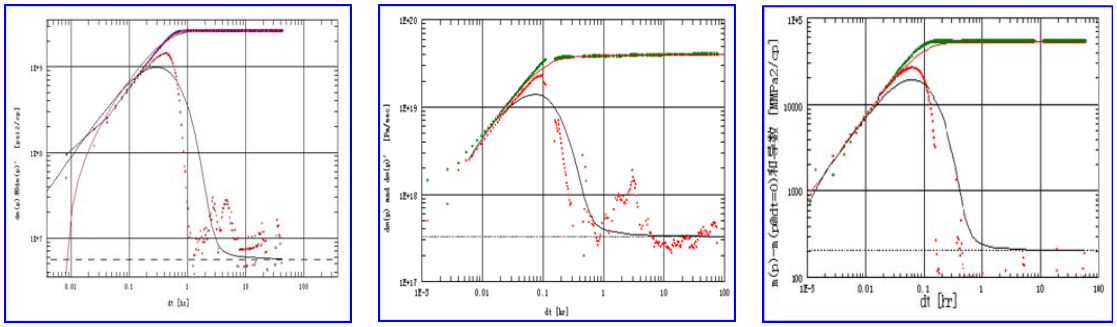
Table 4. Statistics of interlayers in Keshen-2 gas field

Well	Thickness of strata (m)	Mud interlayer					Sand interlayer					Sum			
		Amount	Thickness (m)	Density (m/m)	individual Thickness (m)		Amount	Thickness (m)	Density (m/m)	individual Thickness (m)		Amount	Thickness (m)	Density (m/m)	individual Thickness (m)

KS2	215.5	33	36.5	0.17	1.11	57	57.9	0.27	1.02	90	94.4	0.44	1.05
KS201	306	50	31.9	0.10	0.64	62	96.4	0.32	1.55	112	128.3	0.42	1.15
KS202	300	53	36.3	0.12	0.68	68	85.7	0.29	1.26	121	122	0.41	1.01
Mean	273.8	45.3	34.9	0.13	0.77	62.3	80	0.29	1.28	107.7	114.9	0.42	1.07

5.5 Connectivity of reservoir

According to the above research, the characteristics of Keshen-2 gas field are fracture development, high fracture density, thin thickness of interlayers and limited extending distance. From the well testing data, the reservoir shows the homogeneous infinite formation and there are no signals which show the interbedded characters (Fig.6). In the regional area, Dabei gas field has thicker interlayers than Keshen-2 gas field but the whole reservoir of Dabei gas field shows connective feature. While the fracture system in Keshen-2 gas field is more developed than Dabei gas field, it can presume that the connectivity of reservoir is better than Dabei gas field. The conclusion can be given that the Keshen-2 gas field has good connectivity in the reservoir.



KS2 well KS202 well KS201 well

Fig. 6 Well testing data of three wells

Conclusions

(1) Keshen-2 gas field has giant thickness of sandstone reservoir and the thickness is above 300m which is the basement for the gas accumulation.

(2) The lithology of Keshen-2 gas field in Bashijiqike formation is lithic-feldspar or feldspar-lithic sandstone. The whole reservoir characters poor physical property, developed fractures, undeveloped barriers and interlayers which have no effective isolation for the reservoir. The connectivity of reservoir was presumed good and it is favorable to the development of natural gas resource which need to further research in the next works.

(3) Keshen-2 gas filed is in the early stage of development and has no sufficient data and drilling wells to support the research works. Analogy with the regional gas field such as Dabei and Kela-2 gas field is feasible way to carry out the research work of reservoir.

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