Application of monitoring method in the establishment and maintenance of gas cap injection barrier in a Oilfield

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Abstract. In order to make technical reserves for developing gas cap and buffer zone in A Oilfield and explore effective development methods of gas cap reservoir, according to the overall development idea of oil-gas ring, a field test of gas cap injection and polymer barrier development buffer zone in Layer B was carried out in the structural axis of South Block in 2006. The test adopted the development mode of gas cap injection and polymer barrier development buffer zone, that is, the barrier was established by injecting polymer solution at the oil-gas boundary to separate natural gas from crude oil in buffer zone and keep relatively stable. In this paper, the morphological changes during the establishment and maintenance of barriers are found out by means of monitoring.

Keywords: Oilfield a, oil invasion and gas channeling, accumulation barrier, pressure, change

1. Barrier formation stage

1.1 Barrier formation

The development of foreign gas cap oilfields mostly takes the form of water barrier. Considering that polymer flooding has become a mature technology in Daqing Oilfield, polymer solution is used to replace water to form polymer barrier near the oil-gas boundary. From the numerical simulation results, the average pressure difference between the barrier accumulation allowable gas zone and the buffer zone is 2 ~ 3Mpa, and the pressure of the weakest part is about 2MPa (the pressure of water barrier is about 0.6MPa).

The barrier gathering scheme of the gas cap polymer injection test area of oilfield A is designed as that barrier wells are arranged in the gas area about 100m away from the outer oil-gas boundary, 34 wells are arranged, the well spacing is 75m, the molecular weight is 19 million, the concentration is 2000mg / L polymer solution is injected, and the average injection allocation of a single well is 97m3 / d. under the condition that the gas cap gas is not exploited temporarily and the pressure on both sides of the barrier is relatively balanced, it is expected to form a stable barrier in 4-5 months, The width is about 100m. Polymer injection was started simultaneously on November 10, 2007 for 5 consecutive months.

1.2 Using monitoring results to determine the formation of obstacles

In order to determine whether the accumulation barrier is formed, the gas density test is carried out by monitoring means to determine whether the accumulation barrier is formed and its basic shape.

From the comparison results of neutron lifetime logs of monitoring wells located in the barrier strip before polymer injection and 4 months after polymer injection, it can be seen that the recording value of thermal neutron density has decreased compared with that before polymer injection, indicating that the pores of gas layer are gradually filled with polymer solution, and the natural gas in barrier strip is separated by polymer.

After polymer injection in barrier wells for more than 4 months, the average number of thermal neutron density decreased from 181API before polymer injection to 168API, with an average decrease of 13API. Among them, the maximum value of average counting decline is 50API, 84.4% of the layers show a downward trend, and 63% of the layers fall above 10API. Among them, the maximum count of thermal neutron density in thick layer of oil layer B decreased by 24API and the minimum count decreased by 12API；; The thermal neutron density count of the thin layer of oil layer B decreased by 12API, indicating that the natural gas in the target layer was separated by polymer, and the barrier was relatively uniform.

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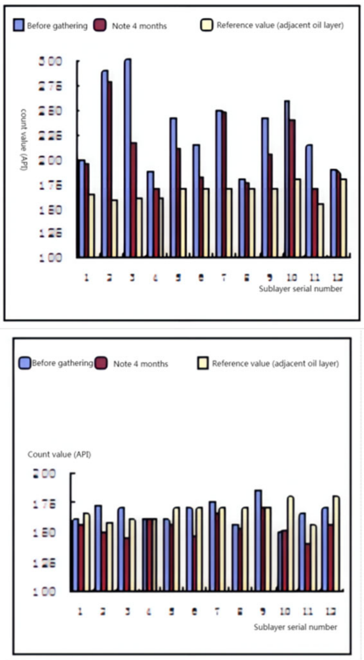


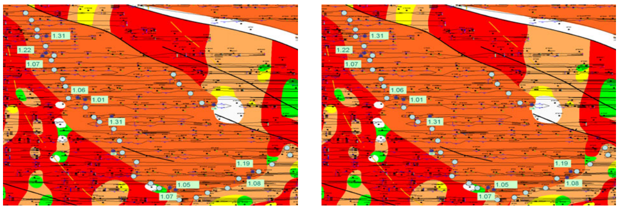
Fig. 1 Test results of thick layer counting of neutron-neutron monitoring wells in barrier band

Neutron-neutron logging was carried out in 10 monitoring wells 35 ~ 75 m away from the barrier wells. Among them, 7 wells located on both sides of the barrier were tested, 2 wells less than 40m, with neutron-neutron test results of 1.06 and 1.07, respectively. The fluid was interpreted as liquid, and 2 wells 40 ~ 50m away from the barrier were tested with neutron-neutron test results of 1.01 and 1.05, respectively, and the fluid was interpreted as liquid. There are 3 wells 50 ~ 60m away from the barrier-gathering wells, one located at one side of the oil area, with neutron-neutron test results of 1.07, fluid interpreted as liquid, and two located at one side of the oil area, with neutron-neutron test results of 1.31 and fluid interpreted as gas. Three wells located between the barrier wells were tested, and the neutron-neutron test results were 1.08, 1.19 and 1.22 respectively, and the fluid was interpreted as liquid. Note: The pores in the area within 50m on both sides of the barrier-gathering well in Layer B have been filled with polymer, and the pores in the area outside 50m on one side of the gas area are still gas.

The average counting rate of thermal neutron density has decreased, and the barriers of adjacent wells have been connected (Table 1).

Table 1 Decrease of neutron count in monitoring wells at different distances

Distance to barrier gathering well (m)	Number of wells	Neutron counting average (API)	Neutron count decrease (API)
30-40	3	169	15
40-50	5	172	24
50-60	1	166	12
60-70	1	168	14
70-80	1	168	11



Unit 1, floor B   Unit 2, floor B

Fig. 2 Neutron neutron logging results near the barrier belt in the first half of 2008

After 5 months of polymer injection, the microseismic front test was carried out. The extension distance of polymer barrier front to both sides of polymer barrier strip is greater than that between polymer barrier wells, and the main dominant injection direction is one side of gas area; According to the microseismic front test results of two adjacent poly barrier wells, the sweep front of polymer injected into poly barrier wells exceeded the midpoint of adjacent wells in 5 months, indicating that the barrier has been connected.

From the change of gas production of the first row of oil wells outside the gas cap (Fig. 3), the average daily gas production of 27 production wells reached 552m3 at the initial stage of production, and the gas produced is mainly the natural gas in the gas area separated by barriers. With the extension of production time, the daily gas production decreases gradually. After three months of production, the average daily gas production of a single well drops to 381m3, and then the average daily gas production of a single well is less than 350m3. In August 2015, the average daily gas production of a single well was 115m3 / D, and there was no abnormality in the gas production of a single well. In addition, the gas oil ratio of the first row of production wells outside the gas cap is higher at the initial stage of production, which decreases significantly after a period of production and tends to be stable. The average gas oil ratio in August 2015 was 65m3 / T. The above analysis shows that after the buffer zone is developed and put into operation, the gas volume of the gas cap separated by the barrier outside the barrier strip continues to decrease, while the gas cap gas in the strip does not flow to the buffer zone outside the strip through the barrier, and the barrier strip is closed.

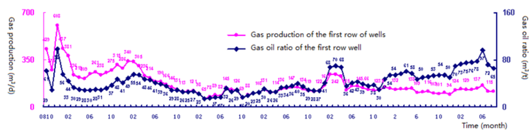


Fig. 3 G+as production variation curve of the first row of oil wells outside the gas cap of the buffer zone

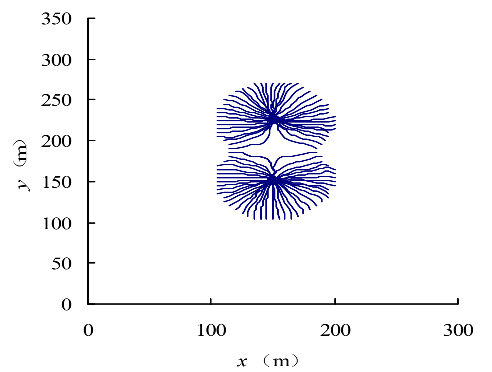
At the same time, the gas composition of 27 production wells in the first row outside the gas cap was tested. The tested methane content was less than 95%, and the average methane content was 86.4%, indicating that the gas produced by the first row of production wells was mainly dissolved gas, and the gas cap gas did not flow to the buffer zone through the barrier.

After the barrier was established in May 2008, it was transferred to the maintenance stage. At the same time, the injection and production wells in the buffer zone were put into operation. By December 2008, all production wells in the whole region were put into operation. From production to now, all wells in the buffer zone have been in normal production without gas channeling.

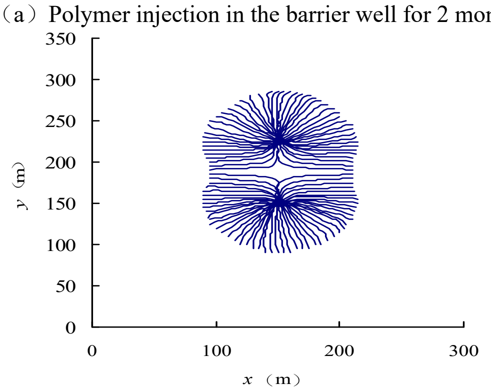
2. Obstacle accumulation maintenance stage

2.1 The barrier has weak areas.

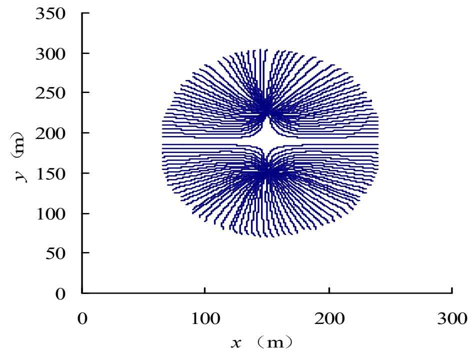
Streamline distribution can reflect the movement track of polymer solution injected from the reservoir in the reservoir, which is helpful to understand the spread law of polymer solution injected into the formation during the establishment and maintenance of accumulation barrier, and provides an important basis for studying the distribution law of multi-well interference seepage field. The flow field distribution diagram of two barrier-gathering wells injected at the same time is simulated (Fig. 4). From the streamline distribution map, it can be seen that due to the superposition of pressure drop in the center area of the two barrier-gathering wells, the driving pressure is close to zero, and it is difficult for polymer to reach this area. Therefore, there is an area with sparse streamline, and the streamline bends more seriously as it approaches the center of the two barrier-gathering wells, thus becoming the weak link of barrier-gathering.



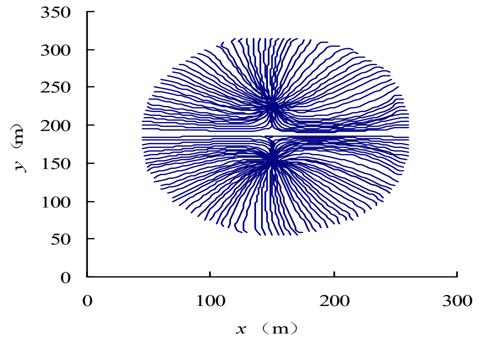
（a）Polymer injection in the barrier well for 2 months



（b）Polymer injection in Juba well for 3 months



（c）5 months of polymer injection in Juba well



（d）13 months of polymer injection in Juba well

Fig. 4 Streamline distribution in formation at different injection time

In fact, the plane development of sand body is not homogeneous. Due to the influence of sand body connectivity, pore size, pressure field distribution, polymer and gas physical properties and other factors, there is incomplete displacement or failure of polymer in the process of reservoir displacement of natural gas, which has become a weak link of polymer barrier.

According to the actual development experience of foreign gas cap oilfields, combined with the results of numerical simulation and the characteristics of fluid physical properties, it is considered that after the barrier is established, under the condition of no polymer injection in the exploitation buffer zone of gas cap, due to the effects of gravity, capillary force and so on, the phenomenon of liquid loss and gas filling will occur in the edge area of the barrier, so it is necessary to inject a certain amount of solution to supplement the barrier to ensure the effective closure of the barrier. According to the well pattern deployment in the test area, the first row of wells in the buffer zone outside the barrier accumulation zone are oil producing wells. Through the ideal model study, draw the distribution diagram of single well pressure field affected by the production of the first row of wells whose buffer zone is close to the accumulation barrier (Fig. 5). It can be seen from the figure that the pressure drop formed between these oil producing wells and barrier accumulation wells will push the barrier accumulation front to the buffer zone. Therefore, in the development stage of buffer zone after the barrier accumulation is established, the barrier accumulation well needs to inject a certain amount of solution to supplement the fluid volume produced by the oil well and maintain the stability of the barrier accumulation zone.

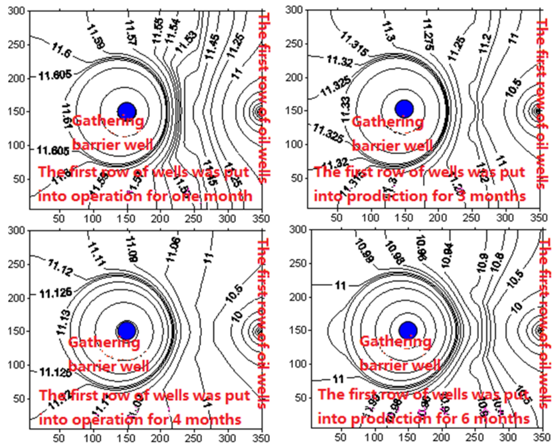


Fig. 5 Distribution diagram of formation pressure field in the first row of wells outside the accumulation barrier at different production times

In addition, after the test area is developed and put into production, the pressure in the block and different well groups will change, and the pressure difference on both sides of the barrier will change constantly, and there is a certain leakage risk in the barrier. Therefore, the polymer barrier needs reasonable maintenance to ensure that the barrier is effective and stable in bearing pressure.

2.2Using monitoring results to find out the weak areas and morphological changes of obstacles

One is to use isotope logging data to find weak parts. According to the statistics of isotope logging data of multi-barrier wells in 2007, due to factors such as large differences in permeability and similar formation pressures in the upper and lower parts, the water absorption intensity in the upper and lower parts of the two sedimentary units of Layer B 1 and Layer B 2 is quite different, reaching 4.1 m3/d.m and 5.4 m3/d.m respectively, while the porosity difference between the upper and lower parts of the two sedimentary units is only 0.4% and 0.2%, which indicates that there is a difference in the amount of polymer entering the pores with the same volume.

Table 2 Strength of water absorption profile of Juzhang well

Project		Average single well												
						Vk≥6			6>Vk≥3			3>Vk		
		Sandstone (m)	Effective (m)	Water absorption strength (m3/d.m)	Porosity (%)	Effective (m)	Permeability (μm2)	Water uptake strength (m3/d.m)	Effective (m)	Permeability (μm2)	Water uptake strength (m3/d.m)	Effective (m)	Permeability (μm2)	Water uptake strength (m3/d.m)
Floor B	Upper part	1	0.8	6.5	29.8	0.8	0.103	2.1	1.1	0.203	5.8	1.1	0.268	7.9
	Lower part	1.5	1.3	10.6	30.2	1.3	0.682	9.8	1.5	0.627	11.9	1.7	0.551	10.5
	Difference			4.1	0.4			7.7			6.1			2.6
Floor B	Upper part	1.2	1	10.2	30.2	1	0.132	6.7	1.1	0.201	9.1	0.9	0.296	11.2
	Lower part	2.1	1.6	15.6	30.4	1.8	0.754	13.9	1.4	0.652	15.2	1.7	0.711	16.9
	Difference			5.4	0.2			7.2			6.1			5.7

The second is to use neutron neutron logging data to clarify the morphological changes of coalescence barriers. Neutron neutron logging data shows that the barrier width is not less than 80m. Statistics of neutron neutron neutron logging data since 2008, among which the test results of underground fluid at well points between gathering barrier wells have always been liquid; The underground fluid test results of well points within 40m from the barrier gathering strip have always been liquid; More than 60% of the well points between 40m and 50m away from the barrier accumulation belt are liquid, and the test results have been liquid since the second half of 2014; 60% of the wells between 50m and 60m away from the barrier gathering strip are tested as liquid. Therefore, the results of neutron neutron logging data show that the barrier width has been maintained at more than 80m, and the barrier width in some areas has reached more than 120m.

Table 3 Neutron neutron logging results over the years

Time	Strip			40mnei			40m ~ 50m			50m ~ 60m		
	Gaseity Number of wells (mouth)	Liquid state Number of wells (mouth)	Gas liquid state Number of wells (mouth)	Gaseity Number of wells (mouth)	Liquid state Number of wells (mouth)	Gas liquid state Number of wells (mouth)	Gaseity Number of wells (mouth)	Liquid state Number of wells (mouth)	Gas liquid state Number of wells (mouth)	Gaseity Number of wells (mouth)	Liquid state Number of wells (mouth)	Gas liquid state Number of wells (mouth)
2008Shang		3			2			2		2	1	
2008Xia		3			2			2		2	1	
2009Shang		4			3		1	2		2	2	
2009Xia		4			3		1	2		2	2	
2010Shang		4			5		1	4	1	3	4	
2010Xia		4			5		1	4	1	3	4	
2011Shang		4			8		1	4	1	2	4	
2011Xia		4			8		1	4	1	2	4	
2012Shang		4			10		1	4		2	4	1
2012Xia		4			10		1	4		2	4	
2013Shang		4			10		2	6	1	3	5	
2013Xia		4			10		2	7		3	5	
2014Shang		4			10		1	10	1	4	5	1
2014Xia		4			10			10		3	6	
2015Shang		6			10			10		3	7	
2015Xia		6			12			11		3	7	

Third, use pressure data to identify key special areas and strengthen maintenance. On the southeast side of the block (Figure 6), the elevation of micro-amplitude structure is high, there are two small gas caps in the buffer zone, and there are situations of large gas volume and low pressure in production. In order to prevent gas channeling, the neutron-neutron test monitoring frequency corresponding to the region is increased, and the maintenance amount is also increased, with emphasis on wells with large differences in oil layer properties between upper and lower parts of Layer B 1 and Layer B 2. For example, Well La 4-303, which is located in the test area of the development buffer zone for polymer barrier injection in the gas cap of Layer B, has a large gas output in July 2013. After detection and analysis, it is not caused by the gas escaping from the gas cap in the polymer barrier injection test, but in order to prevent it, the four surrounding polymer barrier wells have been maintained once.

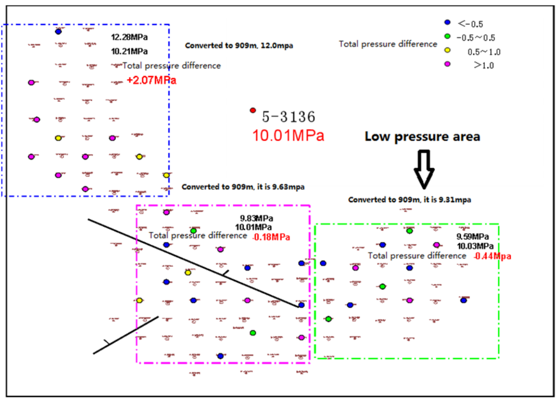


Fig. 6 Pressure distribution of block

3. Barrier gathering maintenance effect

3.1 Out channeling of top gas without gas generation

Since the block was put into operation in August 2008, the daily gas output of the first row of oil wells outside the gas cap has gradually decreased, and the gas oil ratio has been kept below 100m3 / T, which is close to the gas oil ratio of oilfield a, indicating that the gas in the gas cap has not channeled to the buffer zone outside the strip through the barrier, and the barrier strip is closed.

3.2 The barrier gathering width has been kept above 80m

The edge detection test shows that the barrier gathering width is not less than 80m. In June 2015, edge detection tests were carried out on 10 barrier wells, and three edge wells were determined. Among them, the detection edge distance of well l5-ps3204 is 26.04m. Because the well is close to fault 56, it is considered that it is the distance between polymer injection well and fault, and the detection edge distances of well C and well D are 43.03m and 39.82m respectively, which is considered to be the closest distance between polymer front and wellbore. Therefore, The edge detection test results show that the barrier gathering width is not less than 80m.

4. What do you know

First, the monitoring means at this stage can meet the requirements of each stage of obstacle gathering;
Second, reasonable and orderly monitoring shall be carried out in the formation stage of accumulation barrier, so as to provide basis for the formation and sealing of accumulation barrier and lay the foundation for the polymer injection test in buffer zone;
Third, regular monitoring of barrier accumulation can timely find weak areas and abnormalities of barrier accumulation, provide basis for reasonable maintenance, and ensure stable barrier accumulation and no mutual channeling of oil and gas.

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