Distribution of Shallow Gas Reservoirs and Preventive Measures for Blowout in Lamadian Oilfield

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Abstract. Shallow gas is developed in Lamadian oil field, its depth is shallow, and the upper channeling speed is fast. Blowout and gushing are very easy to occur in the process of drilling, especially the blowout accident. By studying the geological conditions of Lamadian Oilfield, the distribution law of shallow gas reservoirs and the controlling factors affecting the distribution of shallow gas reservoirs in Lamadian Oilfield, this paper explores and summarizes the methods for preventing shallow gas blowout in Lamadian Oilfield. Practice has proved that shallow gas reservoir prediction technology and blowout prevention measures have greatly reduced the drilling risk and provided security for drilling.

1. Introduction to regional geology

1.1. Regional structure survey
Lamadian Oilfield is located at the northernmost end of Daqing placanticline in the central depression of Songliao Basin. It is a multi-reservoir heterogeneity seriously sandstone oilfield controlled by structure. The whole structure is short-axis anticline as a whole, the east wing is gentle and the west wing is steep, the east wing is inclined to 6 degrees, and the west wing is inclined to 18 degrees to 22 degrees. The north end is tilted northward at 4 degrees, the southern tip is less than 1 degrees, and its saddle is connected to the Saertu structure. The whole structure is cut into north, middle and south big blocks with different areas by the three faults of 37#, 39# and 51# extending in the north west direction. There are 73 faults in the area. The extension direction of the faults is oblique intersected with the tectonic axis, mainly in the NW-trending group, and the other in the NW-trending scattered small faults. All faults are normal faults. The length of fault extension is generally 1km~2km, and the maximum length can reach 6km. The fault distance is generally 10m~20m, the maximum breaking distance is more than 150m, and the dip angle of fault plane is generally about 50 degrees.

1.2. Sedimentary characteristics of shallow gas reservoirs
The shallow gas in the Lamadian oil field mainly refers to the gas contained in the NenⅢ to the NenⅣ sections. The longitudinal direction of the gas reservoirs even extends from the sandstone in the upper part of the NenⅢ section to the bottom part of the Quaternary. The buried depth is about 50m-660m. The sedimentary processes of the Nenjiang Formation was retreated and contracted from bottom to top, reflecting the sedimentary process of Lake Basin from water inflow to regression. The formation of
Nenjiang Formation was composed of three reverse cycles of grey-white sandstone, siltstone and grey-to-black sandy mudstone and mudstone. The lithology of Nenjiang Formation was grey-green, grey-white sandstone, siltstone and grey-green mud. Interbedded rock, upper Jia Zihong, brown red mudstone, lower gray black and gray mudstone.

2. Control elements affecting the distribution of shallow gas layers

2.1. Structural factors
From the structural diagram, shallow gas layers are distributed at high structural positions, and structural factors play a decisive role in the accumulation. Shallow gas layers are developed only above a certain structural height. The Lamadian oilfield is an asymmetrical short-axis anticline with high axis and low wings. Oil, gas and water are separated by gravity. Natural gas accumulates at the top of the anticline, i.e. the structural high point.

From the point of view of hydrocarbon migration and accumulation, faults play two main roles in shallow gas formation, one is to block the accumulation of natural gas, the other is to play a channel role in natural gas migration [1]. At the same time, the influence of fault has changed the structural depth of each fault block, so that the gas bearing depth of each fault block is different.

![Figure 1. Sealing effect of anticline nose structure on gas accumulation](image1)

![Figure 2. Sealing effect of fault on gas accumulation](image2)
2.2. Lithologic factors
The distribution of shallow gas layers is also related to lithological factors. The NenⅢ and NenⅣ sections are dominated by sandstone, and the sand layer is thick. The pores between the sandstones provide a favorable space for the storage of natural gas, and also provide favorable channel for gas migration upward. The drilling site shows that the thickness of sandstone with blowout and gas invasion is relatively large.

3. Development of shallow gas reservoirs in Lamadian oilfield
According to the geological stratification data, structural conditions and drilling data in the western part of the south-middle block of Lamadian oilfield, shallow gas reservoirs are developed in the upper part of NenⅡ section, with an altitude of -510m (equivalent to well depth 660m). The shallow gas layers are divided into three types according to the depth of the top of NenⅡ section.

The main high-pressure area (red area) of shallow gas reservoirs: the top altitude depth of NenⅡ member is above 420m, which is equivalent to the top well depth of NenⅡ member is above 600m.

Shallow gas reservoir high pressure area (blue area): the top altitude depth of NenⅡ member is -450m~480m, which is equivalent to the top well depth of NenⅡ member is 600m~630m.

The main gas-bearing area of shallow gas reservoir (yellow area): the top altitude depth of NenⅡ member is -480m~510m, which is equivalent to the top well depth of NenⅡ member is 630m~660m.

4. Prevention of shallow gas blowout
Blowout is a catastrophic accident with huge losses and bad effects. Once a shallow gas well blowout accident occurs, it will cause serious consequences, such as equipment buried, casualties, waste of oil and gas resources, borehole scrap, environmental pollution and a large number of capital losses [2].

According to the underground geological conditions in Lamadian area and the experience gained in drilling operation, five methods suitable for shallow gas blowout prevention in this area are summarized.

1) Rational design of well bore structure. For predicting wells located in shallow gas reservoirs, casing in the lower surface layer should be required to seal the upper unconsolidated formation while protecting the shallow water layer so that the cement can return to the surface and ensure good sealing quality.

2) Install well control device. After the reasonable well structure is determined according to the geological design, the well control device is selected according to the predicted maximum surface pressure.

3) Reasonable design of drilling fluid density. Must make the drilling fluid column pressure slightly greater than the formation pressure, this slightly greater pressure at least to offset the drilling suction pressure, drilling fluid density in accordance with the prescribed 0.07g/cm3~0.15g/cm3 high added value.

4) Strictly control the pulling out speed, and the pulling out speed will cause the blowout.

5) The shorter the time to stop the circulation in the well, the better. The drill must be drilled immediately after pulling out.

5. Field application
After 2015, 853 wells have been distributed in Lamadian Oilfield, of which 808 wells are located in shallow gas zone. All the design Wells are under the surface casing, and the surface casing goes down to the stable mudstone below the shallow water layer, with a depth of 100m~200m ; With proper drilling fluid density, the drilling fluid density in Lamadian shallow gas zone is generally 1.20g/cm3~1.25g/cm3 for the first drilling ; Strictly control the pulling out speed ; Drilling immediately after pulling out. The actual situation shows that after 2015, the complexity rate of shallow gas reservoir accidents has been greatly reduced.
6. Conclusion

(1) The shallow gas layer of lamadian oilfield is an anticline sandstone gas reservoir. Structural factors play a decisive role in the formation of gas reservoirs. The development of anticline and fault is favorable for the accumulation of natural gas. At the same time, lithologic factors play a certain role in the distribution of gas, making the distribution of shallow gas more complicated.

(2) Most of the vertical development Wells of shallow gas layer in lamadian oilfield are concentrated in the formation of nenⅣ to nenⅢ. The plane is mainly distributed in the top of the anticline and the structural traps with fault occlusion.

(3) Combined with the distribution law of shallow gas, taking corresponding preventive measures can effectively avoid the occurrence of shallow gas blowout.

References

[1] Sun Qingping, Understanding of Shallow Gas Reservoir in Lamadian Oilfield [J]. Daqing Petroleum Geology and Development, 2002,2(4)
[2] Zhang Houfu, petroleum geology [M]. Beijing: Petroleum Industry Press, 1999.
[3] Jiang Xiwen compilation, drilling accidents and complex problems [M]. Beijing: Petroleum Industry Press, 2001.
[4] Yang Shoushan, Actively Protecting High-Productive Oil and Gas Reservoirs, Scientific Measures to Prevent Blowout, Journal of Jianghan University of Petroleum Workers, 2002/01