Study on the Distribution of Sand Body and Fluid in Shallow Stratum of a Development Area

Li Qingshan
The First Oil Production Plant of Daqing Oilfield Corp. Ltd.

Abstract: This paper explores the distribution of sand body, fluid and formation pressure in the shallow stratum of a development area through MDT formation tests and logging data, which provides a basis for finding new petroleum geological reserves and preventing casing damages of oil-water wells.

1. Introduction
In the late development stage of oilfield with high water content, the contradiction of high comprehensive water content and insufficient reserve resources is further intensified, and the difficulty of stable production is obviously increased. In order to meet the needs of the sustainable development of the oilfield, it is necessary to find new petroleum geological reserves in the upper part of the oil formation in a development area. In order to clarify the oil and gas production potential of the upper oil formation and find new petroleum geological reserves, it is necessary to conduct a study on the distribution of the sand body and fluid above the oil formation of the development area because there is no clear understanding of the fluid in the reservoir above the oil formation of the development area, especially the shallow gas.

2. Distribution of sand body and fluid in shallow stratum based on conventional logging data

2.1 The development of the stratum
The section is drilled from top to bottom with Quaternary and 4th, 3rd and 2nd members of Nenjiang Formation of Lower Cretaceous. The strata of Tertiary, Mingshui Formation of Upper Cretaceous and the 5th member of Nenjiang Formation of Lower Cretaceous are missing.

2.2 Development of sand body in shallow stratum based on conventional logging data
In order to study the development of sand body in the shallow stratum of a development area, the conventional logging curve of shallow stratum of 10 wells of the new drilling area in production area X is measured, and the sand body thickness and fluid distribution in the shallow stratum are analyzed. The results show that the thickest sandstone is the 4th member of Nenjiang Formation, with an average thickness of about 90 meters, followed by the 3rd member of Nenjiang Formation and the 1st member of Mingshui Formation, with an average thickness of about 20 meters; the 2nd member of Nenjiang Formation, the Sifangtai Formation, the 2nd member of Mingshui Formation and the Quaternary are relatively thin with an average thickness of about 10 meters. The fluid is dominated by water layer. From the 1st member of Mingshui Formation to the 4th member of Nenjiang Formation, there are some suspected aeration zones, but it is not obvious.
3. Fluid properties of shallow stratum based on MDT formation test data

3.1 Fluid properties obtained by MDT formation test
The MDT formation test is carried out of well A in the new drilling area. Four representative positions with high resistivity and good permeability of the logging curve of shallow stratum are sampled. For the test results of four sampling points, all of them are water layers (Table 1), and the mineralization of water sample is about 2000mg/L, which shows that the fluid in shallow stratum is mainly formation water, and the high resistivity value is related to lithology.

Table 1 Laboratory test and analysis results of MDT sampling of well A

| Number | Depth | PH value | CO₃²⁻ mg/L | Cl⁻ mg/L | Ca²⁺ mg/L | k⁺ Na⁺ mg/L | Total Mineralization mg/L | Oily Wastewater mg/L | Density g/cm³ | Viscidity MPa.s |
|--------|-------|----------|------------|----------|-----------|-------------|--------------------------|---------------------|--------------|----------------|
| 1      | 324.7 | 8.00     | 150.03     | 283.60   | 6.01      | 476.10      | 1409.92                  | 5.71                | 989.76       | 1.1            |
| 2      | 371.4 | 7.87     | 135.02     | 407.68   | 6.01      | 587.65      | 1742.13                  | 1.67                | 990.21       | 1.2            |
| 3      | 418.0 | 7.94     | 165.03     | 620.38   | 6.01      | 725.65      | 2061.81                  | 5.84                | 991.62       | 1.2            |
| 4      | 486.5 | 7.95     | 150.03     | 1001.46  | 8.02      | 960.25      | 2676.17                  | 3.52                | 991.20       | 1.1            |

3.2 Distribution of formation pressure
18 wells are selected for substrata pressure test in the new drilling area in production area X, among which 15 wells obtain substrata pressure not only in oil formation, but also in shallow stratum. Based on the analysis of the formation pressure of nine wells [1], we have a preliminary understanding of the vertical and horizontal distribution of the formation pressure in shallow stratum.

3.2.1 Changing trend of vertical pressure in shallow reservoir stratum
Based on the pressure data of nine wells, the profile of pressure trend of shallow reservoir in each single well is drawn. The formation pressure in the shallow stratum of all wells basically keeps the stepwise change trend of "gradually increasing from shallow to deep stratum". In some wells, the formation pressure fluctuates at individual measuring points of some strata, showing higher or lower data. The fluctuation of formation pressure changes greatly of measuring points at different depth, which deviates from the normal trend, especially in the 2nd member of Nenjiang Formation.

3.2.2 Changing trend of horizontal pressure in shallow reservoir stratum
Based on the weighted average processing of the pressure data of the 4th, 2nd and 3rd members of Nenjiang Formation of nine wells, the formation pressure isogram of the three members is drawn. On the plane of the 2nd member of Nenjiang Formation, there is a great difference in formation pressure between regions, while on the plane of the 4th member and the 3rd member of Nenjiang Formation, there is a little difference in formation pressure between regions. The great difference of formation pressure between regions on the plane of the 2nd member of Nenjiang Formation may be one of the reasons for the casing damage.

3.2.3 Analysis of formation pressure of each member in shallow stratum
a. Formation pressure of Sifangtai Formation
The formation pressure of Sifangtai Formation has been obtained from only five measuring points of four wells. The formation pressure values of all measuring points in Sifangtai are lower than the corresponding original pressure values, with the maximum and minimum formation pressure values of 1.5MPa and 0.9MPa respectively. There is little difference in formation pressure between wells.

b. Formation pressure of the 4th member of Nenjiang Formation
The formation pressure of the 4th member of Nenjiang Formation has been obtained from nine
wells, with the most detailed pressure measuring points. The formation pressure values of all measuring points in the 4th member of Nenjiang Formation are lower than the corresponding original pressure values, with the maximum and minimum formation pressure values of 5.2MPa and 1.1MPa respectively. There is little difference in formation pressure between wells.

c. Formation pressure of the 3rd member of Nenjiang Formation

The formation pressure of the 3rd member of Nenjiang Formation has been obtained from five wells. Except that the formation pressure value of the 4th member of Nenjiang Formation of well K is higher than the corresponding original pressure value, the formation pressure values of all measuring points of other wells are lower than the corresponding original pressure values, with the maximum and minimum formation pressure values of 6.5MPa and 4.4MPa respectively. There is little difference in formation pressure between wells.

| Well Number | Formation Depth | Formation Position | Formation Pressure (MPa) | Initial Reservoir Pressure (MPa) |
|-------------|-----------------|--------------------|--------------------------|---------------------------------|
| F           | 673.5           | N2 bottom          | 10.3                     | 7.9                             |
| E           | 537.0           | N2 top             | 6.8                      | 6.8                             |
| D           | 512.5           | N2 top             | 7.7                      | 6.6                             |
| B           | 712.0           | N2 bottom          | 10.6                     | 8.2                             |
| C           | 716.5           | N2 bottom          | 11.2                     | 8.3                             |
| D           | 480.5           | N2 top             | 4.4                      | 6.4                             |
| C           | 678.0           | N2 bottom          | 2.7                      | 8.0                             |
| A           | 486.2           | N2 top             | 5.4                      | 6.4                             |
| A           | 491.0           | N2 top             | 5.7                      | 6.5                             |

d. Formation pressure of the 2nd member of Nenjiang Formation

The formation pressure of the 2nd member of Nenjiang Formation has been obtained from six wells (Table 2). The difference in formation pressure of the 2nd member of Nenjiang Formation between different wells and between the bottom and the top is relatively large. The abnormal high-pressure layer which is much higher than the original formation pressure often appears at the bottom. For example, the maximum formation pressure at the bottom of well B is 11.2MPa. The abnormal high-pressure layer at the bottom of the 2nd member of Nenjiang Formation is often caused by the soakage of the index bed [2]. The occurrence of abnormal high-pressure formation causes the plane difference of formation pressure between regions or between wells to increase, which is easy to cause casing damage at the index bed.

4. Gas-bearing status of shallow stratum based on sidewall coring and gas logging data

In order to study the gas bearing in the shallow stratum of a development area, five wells are selected for sidewall coring and gas logging in new drilling area X.

According to logging data [3], shallow gas is common in this area. Different degrees of gas logging anomalies are found at the top of the 4th, 3rd and 2nd members of Nenjiang Formation, but the production capacity is low, so the industrial gas production is unlikely. The lower value of gas logging data is mainly caused by the insufficient energy of underground gas reservoir and poor logging conditions, where shallow gas cannot form a scale.

Based on the comprehensive analysis of the fluorescence micrograph data, sidewall coring, rock pyrolysis, gas chromatography data and gas logging data of the five wells in the section, combined with the regional data, it is considered that the section has casing damage in different degree in the 2nd member of Nenjiang Formation.

5. Conclusion

(1) The MDT formation test confirms that the fluid in shallow stratum is mainly formation water.
(2) The MDT formation test data can be used to analyze the distribution of formation pressure in each shallow stratum. The comprehensive analysis of multiple data shows that there are casing damages in different degrees in the 2nd member of Nenjiang Formation, which can provide basis for the prevention and treatment of casing damages in oil-water wells.

Author introduction
Li Qingshan (1982-), male, Undergraduate, engineer, mainly engaged in oilfield well-logging interpretation, The First Oil Production Plant of Daqing Oilfield Corp. Ltd.

References
[1] Tan Bisheng, Chen Kegui, et.al. Study on Formation Pressure Evaluation Using Logging Data[J]. Inner Mongolia Petrochemical Industry, 2007(12):89-90.
[2] Cong Yushen. Study on the Relationship Between Inlet Water and Casing Damage of N2 Bottom Oil Shale in Sazhong Development Zone[J]. Inner Mongolia Petrochemical Industry, 2014(5):131-133.
[3] Jiang Qin. Study and Application of Geological Logging Data in Oilfield Interpretation and Evaluation [J]. China Petroleum and Chemical Industry Standards and Quality, 2014(23):95.