Journal of Geoscience and Environment Protection, 2022, 10, 132-138
https://www.scirp.org/journal/gep
ISSN Online: 2327-4344
ISSN Print: 2327-4336

Identification of Interlayer in Strong Bottom Water Reservoir and Its Influence on Development Effect

Jie Tan, Jianbo Chen, Zhang Zhang, Chunyan Liu, Wentong Zhang

Tianjin Branch of CNOOC Ltd., Tianjin, China
Email: 4687610@qq.com

How to cite this paper: Tan, J., Chen, J. B., Zhang, Z., Liu, C. Y., & Zhang, W. T. (2022). Identification of Interlayer in Strong Bottom Water Reservoir and Its Influence on Development Effect. *Journal of Geoscience and Environment Protection, 10,* 132-138.
https://doi.org/10.4236/gep.2022.107009

Received: June 28, 2022
Accepted: July 18, 2022
Published: July 21, 2022

Abstract

X oilfield is located in Bohai Sea area, in which G oil formation is a typical drape anticline structure, which is composed of multiple sets of thick sandy conglomerate and multiple sets of argillaceous intercalation. From the perspective of development effect, muddy interlayer has a great impact on the oilfield. In this paper, through core identification and well logging identification, the electrical discrimination standard is summarized to identify the interlayer. Through statistics and analysis of the production performance of actual wells, the influence of muddy interlayer on the development performance of oil wells is summarized. This study provides guidance for the development of strong bottom water reservoirs with interlayer.

Keywords

Strong Bottom Water Reservoir, Drape Anticline Structure, Interlayer Identification, Development Effect

1. Introduction

Interlayer is one of the key factors causing reservoir heterogeneity, and it is also a necessary research content in the fine characterization of the reservoir. The development of oil field and the formation and distribution of remaining oil in the reservoir are affected by many factors, such as the type of interlayer, vertical and horizontal distribution. Therefore, the research on the identification and characteristics of interlayer in the research area has a very important guiding role and practical value for the next exploitation of the oilfield (Liu & Cheng, 2013; Sun et al., 2020).

At present, most scholars generally agree that the interlayer is an impermeable rock layer with an area greater than half of the flow unit and small thickness restrictions (up to tens of meters thick and tens of centimeters thin), which can effectively block the free movement of fluid between different sand bodies. At the same time, generally speaking, the partition distribution is relatively stable and has good continuity. Interlayer refers to the impermeable rock stratum in the same sand body. Compared with the interlayer, the interlayer area is smaller, generally not more than half of the area of the flow unit, and the thickness is significantly smaller than the interlayer. It ranges from a few centimeters to dozens of centimeters, with poor continuity and unstable distribution. Its blocking effect on the fluid is limited, but it still has a significant impact on the fluid flow in the same sand body. However, when studying the interlayer and interlayer, people usually call the rock strata with low or zero permeability distributed in the reservoir as interlayer (Zheng et al., 2015; Zhang et al., 2011; Qu et al., 2013).

The G oil formation of X oilfield is a northeast trending drape anticline trap, clamped by faults on the East and west sides, and the structure is consistent with the basement morphology. The trap area is large, the trap amplitude is high, and it is relatively complete. Its top stratum is thin and its edge is thick, which is a typical drape anticline structure.

The stratum thickness of oil formation G is 220 - 450 m. On the profile, there is a large set of sandy conglomerate mixed with mudstone. The sand layer is developed, which is characterized by extremely thick sandstone and sandy gravel mixed with thin mudstone. The stratum thickness changes greatly on the plane. The buried depth of G oil formation is 1333 - 1650 m, which is composed of multiple sets of thick sandy conglomerate. An unstable sandstone strip (1 sublayer) is developed in the mudstone at the top of oil formation g, which is limited in distribution and only developed at the West high point. The oil layer is 2.2 - 7.5 m thick with an average thickness of 4.2 m. The main oil layer (2 sublayer) is developed in a set of glutenite with a thickness of nearly 80 m in the upper part of the oil formation. The reservoir is stably distributed. The thickness of the oil layer is 2.7 - 28.3 m, with an average thickness of 19.2 m.

Through the observation and research of core of coring well, it is the most direct (visual observation of core) and accurate (identification thickness is as small as a few centimeters) to identify the interlayer. At the same time, it can clearly see the sedimentary rhythm of the reservoir and the occurrence of the interlayer, but this method is limited by the data of coring well.

The genetic types of interlayers in fluvial reservoirs can be divided into two categories: those formed by sedimentation and those formed by diagenesis. For the shallow and middle sedimentary reservoirs in Bohai oilfield, because of the weak diagenesis, the interlayer is mainly formed by sedimentation. According to the influence mechanism of interlayer, it can be divided into argillaceous interlayer, calcareous interlayer and physical interlayer. From the perspective of development effect, the argillaceous interlayer has a great impact on the oilfield. The calcareous interlayer has little impact on the bottom water reservoir because it is cemented at the bottom, top and near the argillaceous blocks in the reservoir. The physical intercalation is mainly composed of silty mudstone and argillaceous fine and siltstone (Huang et al., 2018; Zhang et al., 2017). This kind of intercalation has certain porosity and permeability conditions, but does not reach the lower limit of physical properties of effective thickness, and its distribution is unstable; In addition, it also includes medium fine gravel, sandstone and disordered conglomerate physical intercalation supported by complex foundation. This kind of intercalation has high shale content, poor physical properties and strong micro heterogeneity. It is mainly residual sediment distributed in the main channel and braided channel, and is formed at the edge or flank of the channel. In view of the retarding effect of argillaceous intercalation and conglomerate intercalation on the rising rate of water cut in bottom water reservoir, it is taken as the key research.

2. Interlayer Identification

The interlayer identification is mainly based on core identification and logging identification, and the electrical discrimination standards (GR, den and CNC) are summarized. Argillaceous intercalation is characterized by high GR, high density and low resistivity (Liu et al., 2009; Luo et al., 2019; Wang et al., 2018).

After the transformation of GR, den and CNC neutron logging curves, it can be seen from the well connection profile that the curve section with both yellow and gray is the mud gravel interlayer section (Figure 1).

The statistical criteria for different electrical properties of argillaceous interlayer, physical interlayer and argillaceous gravel interlayer are as follows (Table 1). From the table, it can be seen that the electrical gamma of argillaceous interlayer and argillaceous gravel interlayer accounts for more than 0.6, the electrical

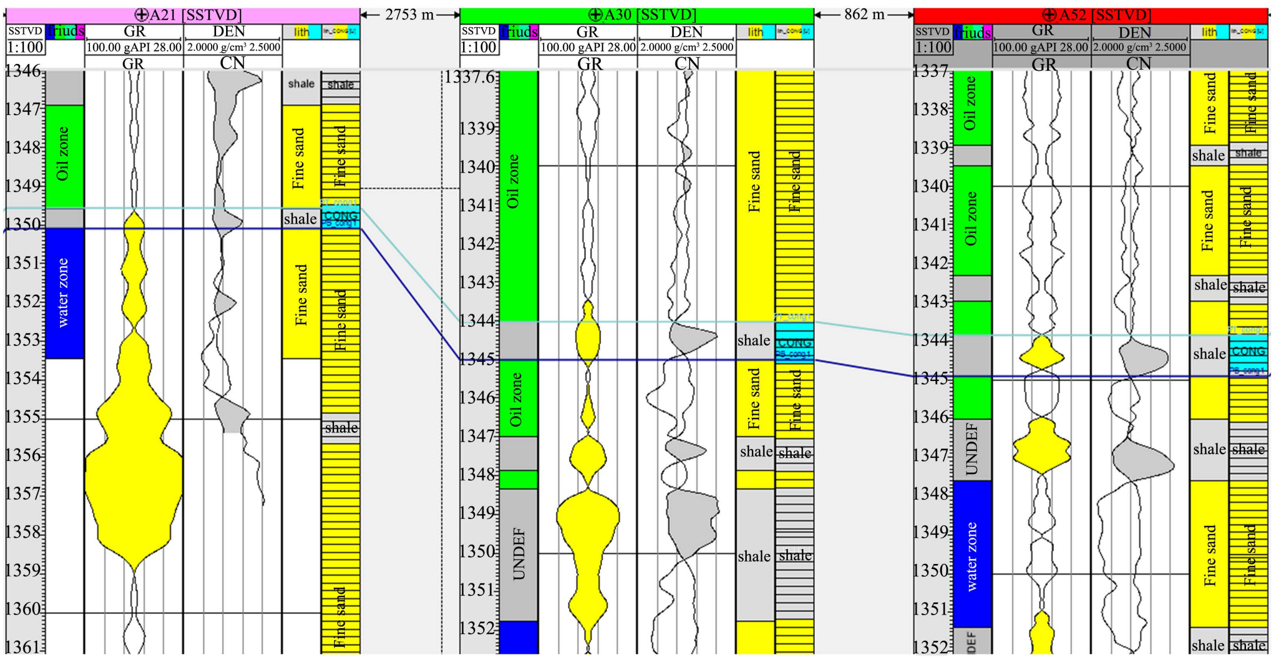

Figure 1. Identification features of well connection profile.

density accounts for more than 0.6, and the electrical neutron accounts for 0.2 - 0.7.

The main criterion for sandstone and mudstone is resistance, and sandstone shows high resistance of 1 - 95 Ω·m. Mudstone mainly has low resistivity and high gamma value, and the resistivity is less than 2 Ω·m. Gamma value is greater than 80; The logging response characteristics of mud gravel interlayer are "three high and one low": high GR, high density, high resistivity, low neutron, and the low neutron value is 14% - 20% (Table 2).

3. Influence of Interlayer on Development Effect

3.1. With Interlayer

For the production well of the first layer with interlayer, the average water cut reaches 90% in 2 years of operation. Due to the slow rise of water content, the average initial water content is 34% (Table 3). The water cut curve is mainly "s" type, and the curve "inflection point" appears at 80%.

The average water cut of the second production well with interlayer reaches 90% in 2 years of operation (Table 4). The water cut curve is mainly of "s" type, and the curve "inflection point" appears at 90%.

3.2. No Interlayer

Without interlayer, the bottom water can quickly form water cone, and the average initial water content is 81.8% (Table 5).

Table 1. Statistical table of electrical discrimination standards for different interlayer.

Type of interlayer	GR	PHIE	PERM	RD	DEN	Neutron
Argillaceous intercalation	>0.7	0.1 - 0.3	<0.2	0.4 - 0.5	>0.6	0.2 - 0.7
Physical interlayer	>0.4	0.2 - 0.5	0.1 - 0.5	>0.5	>0.6	>0.4
Mud gravel interlayer	>0.6	0 - 0.5	<0.2	<0.5	>0.6	0.2 - 0.6

Table 2. Interlayer identification standard of NG III oil formation in X Oilfield.

Types of reservoir and interlayer	GR	CNC	Density	RT
	API	%	g/cm^3	Ω·m
Sandstone	50 - 80	25 - 40	2 - 2.3	1 - 95
Argillaceous intercalation	>80	25 - 45	2.2 - 2.35	<2
Physical interlayer	50 - 65	14 - 25	2.2 - 2.5	1 - 5
Mud gravel interlayer	65 - 80	14 - 20	2.2 - 2.45	>6

Table 3. Production statistics of the 1st sublayer with interlayer.

Well number	Geological parameters					Initial capacity					
	Bottom water thickness	Permeability	Length of horizontal well section	Effective thickness	Height of avoiding water	Production time	Daily liquid	Daily oil production	Water cut	Production differential pressure	Specific oil production index
	m	mD	m	m	m		m^3/d	m^3/d	%	MPa	$m^3/(d\cdot MPa\cdot m)$
A43H	54	649	342	10	16	2006/5/11	135	120	11.1	4	3
A62H	45	1296	289	9	12	2010/9/16	54	51	5.6	3.7	1.5
A8H1	45	743	270	12	8	2015/2/28	106	70	34	2.8	2.1
A54H	54	806	286	9	15	2007/11/18	188	135	28.2	4	3.8
A64H	54	1194	275	10	12	2010/9/24	75	67	26.7	6.7	1
A16H	45	686	376	15	8	2006/5/14	405	214	47.2	5	2.9
A32H	54	1125	378	15	10	2005/10/3	238	129	45.8	3.3	2.6
A49H2	58	823	271	9	12	2010/2/10	100	52	48	8.5	0.7
A5H2	44	552	233	12	7	2015/3/6	92	36	60.9	5	0.6
A4H	57	1423	269	10	12	2004/8/17	123	84	31.7	5.2	1.6
Average								90		5	2

Table 4. Production statistics of the 2nd sublayer with interlayer.

Well number	Geological parameters					Initial capacity					
	Bottom water thickness	Permeability	Length of horizontal well section	Effective thickness	Height of avoiding water	Production time	Daily liquid	Daily oil production	Water cut	Production differential pressure	Specific oil production index
	m	mD	m	m	m		m^3/d	m^3/d	%	MPa	$m^3/(d\cdot MPa\cdot m)$
A4H1	57	786	417	12	25	2008/12/2	343	280	18.4	1.3	17.9
A51H	44	1067	263	12	20	2007/11/17	360	245	31.9	2	10.2
A61H	35	1932	287	10	20	2010/8/2	412	256	37.9	2.6	9.8
A42H1	54	849	239	9	12	2009/9/10	192	116	39.6	2	6.4
A75H2		-	174	8.8	10	2018/9/9	118	65	44.9	1.4	5.3
Average								192		2	10

Table 5. Statistics of production without interlayer.

Well number	Geological parameters					Initial capacity					
	Bottom water thickness	Permeability	Length of horizontal well section	Effective thickness	Height of avoiding water	Production time	Daily liquid	Daily oil production	Water cut	Production differential pressure	Specific oil production index
	m	mD	m	m	m		m^3/d	m^3/d	%	MPa	$m^3/(d\cdot MPa\cdot m)$
A1H1	54	809	377	14	10	2008/11/24	572	76	86.7	1.7	3.2

Continued

A9H1	45	1239	211	17	11	2011/12/31	358	61	83	2.2	1.6
A5H1	57	711	85	8	8.1	2009/12/18	206	39	81.1	3.5	1
A55H	58	1032	352	10	9	2010/5/18	487	33	93.2	6.6	0.5
A48H1	58	584	265	8	3.7	2014/12/11	80	28	65	6.8	0.5
Average								43		4	1.3

4. Summary

1) The interlayer of sandstone reservoir is mudstone, which can be identified by core and logging. The argillaceous interlayer has the characteristics of high GR, high density and low resistivity. The weight of electric gamma of argillaceous intercalation and mud gravel intercalation is greater than 0.6, the weight of electric density is greater than 0.6, and the weight of electric neutron is between 0.2 - 0.7. The main criterion for sandstone and mudstone is resistance, and sandstone shows high resistance of 1 - 95 Ω·m. Mudstone mainly has low resistivity and high gamma value, and the resistivity is less than 2 Ω·m. Gamma value is greater than 80; The response characteristics of mud gravel interbed logging are "three high and one low": high GR, high density, high resistivity, low neutron, and the low neutron value is 14% - 20%.

2) The interlayer of strong bottom water reservoir has a great influence on production performance. The water content of the non barrier interlayer rises rapidly, with an average annual water content of 90% after 14 months of operation. The bottom water can quickly form a water cone, and the average initial water content is 81.8%. When there is a layer of interlayer, the average water cut of the production well is 90% after it is put into operation for 2 years. The water cut curve is mainly of near "s" type, and the curve "inflection point" appears at 90%. When there are two layers of interlayer, due to the slow rise rate of water content, the average initial water content is 34%, and the water content curve is mainly "s" type, and the curve "inflection point" appears at 80%.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Huang, S. J., Song, Q. L., Cheng, L. S. et al. (2018). Study on Interlayer Parameters of Bottom Water Heavy Oil Reservoir under Single-well Condition. *Journal of Southwest Petroleum University (Science & Technology Edition), 40,* 130-139.

Liu, J., & Cheng, L. S. (2013). The Impact of Interlayer to Horizontal Wells Production in Bottom Water Reservoir. *Science Technology and Engineering, 13,* 9662-9665.

Liu, R., Jiang, H. Q., Liu, T. J. et al. (2009). Study on the Influence of Interlayer on the Recovery of Thick Oil Reservoir. *Journal of Southwest Petroleum University (Science & Technology Edition), 31,* 103-106.

Luo, X. B., Li, J. Y., Duan, Y. et al. (2019). Experimental Study on Optimal Location of Drilled Interlayer in Injection-Production Wells with Different Development Methods in Bohai Oilfield. *Petroleum Geology and Engineering, 33,* 87-91.

Qu, Y. G., Liu, Y. T., & Wei, J. (2013). The Analysis of Influencing Factors on Development of Horizontal Wells in Bottom Water Drive Reservoir. *Oil and Gas Well Testing, 22,* 17-19.

Sun, E. H., Yang, D. D., Yang, W. et al. (2020). Numerical Simulation Study of the Effect of Interlayer Parameters on Water Injection in Bottom Water Reservoir—By Taking a Oil Reservoir in Bohai as an Example. *Petroleum Geology and Engineering, 34,* 71-75.

Wang, Y., Zheng, H., Li, H. Y. et al. (2018). Study and Application of Interlayers in Heavy Oil Reservoirs with Edge and Bottom Water in Bohai A Oilfield. *Petroleum Geology and Engineering, 32,* 52-55.

Zhang J. F., Tian, X. D., Guo, W. Q. et al. (2011). Discussion and Application of the Water Cut Increasing Law in Water-Flooding Oilfield. *Drilling and Production Technology, 34,* 49-51.

Zhang, Y. L., Zhang, J. L., Xu Y. N. et al. (2017). Influences of Interlayer on Reservoir Thickness for Horizontal Well Allocation in Heavy Oil Reservoirs with Bottom Watr: A Case from Qinhuangdao 32-6 Oilfield. *Xinjiang Petroleum Geology*, **38**, 729-734.

Zheng, X. J., Shao, G. Y., Chen, D. B. et al. (2015). Influence of Interlayer in the Reservoirs with Strong Bottom Water on Remaining Oil Distribution in Tahe Oilfield. *Journal of Yangtze University (Natural Science Edition), 12,* 68-71.