Logging recognition of the intercalations in Niu 74 Block of Ciyutuo oilfield

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Abstract

Study heterogeneity was the important content of reservoir 3D geological modeling, so study of Intercalations was indispensable.In this paper, based on the physical characteristics of the core, well log data as the basis, the intercalations in the N74 block was divided into two categories.Based on the fine calculation of porosity and permeability, the identification criteria for the identification of the intercalation layer are established. Systematic identification of the N74 interlayer, study the spatial distribution of the intercalations, achieved good results.

Keywords

Niu 74 block,intercalations,logging information.

1. Introduction

The factors affecting the distribution of remaining oil was complicated, seepage barriers and flow differences caused by intercalations in the reservoir was an important factor affecting the distribution of remaining oil[1].Prediction interlayer distribution in space was indispensable contents to reveal the reservoir with anisotropy, direct observation of the core was at the base of the interlayer recognition, but the limited number of core, logging data rich than core data, and there was a higher vertical resolution.

2. Regional geology

Niu 74 block was located in the city of Liaoning Province, 60 km away from Shenyang City, 30 km away from Liaoyang city. The main oil bearing layer was $Es_2$and Es_3.Structure in the middle of the Niu-Qing structural belt, oil-bearing area was2.63km^2 and petroleum geological reserves 491.25 million tons (2005), calibration recovery rate was 7.0%, recoverable reserves of 34.4×10^4t, mainly containing layers of E_{S2} reservoir, with a burial depth of 2950 ~ 3500m, fault block was square well a layer into the development in 2005 by 235m well spacing, in august at the same year into waterflooding [2].

3. Classification and logging response characteristics of the intercalations

The interlayer was distributed in the reservoir impermeable layer or extra low permeability layer, which divides the thick oil layer into a plurality of independent fluid flow units, which influence the flow of the fluid in the reservoir, and are the important factors for the heterogeneity of the reservoir.The interaction of interlayer and other factors can result in watered, water flooding and unused period of coexistence of thick oil reservoir. The existence of the interlayer was conducive to the expansion of the vertical sweep volume and oil displacement efficiency of the positive rhythm and block rhythm reservoir, which was not conducive to the improvement of the water injection and efficiency of the anti rhythm reservoir[3].

As a result of sedimentation, diagenesis and other differences in geological processes, form different types of isolation gap accordingly.According to the lithology and electrical characteristics of well logging interpretation, the intercalations in study area can be divided into two types, such as shale and physical layer.

Applicated core calibration logging technology, established different types of logging identification of the classification criteria was to identify the best and the best way to divide the inner layer of the reservoir[4-5].

3.1 Argillaceous interlayer logging response characteristics

The reason of the formation of theargillaceous interlayer was relate to the dynamic change of the water power,it was generally due to the weakening of the hydrodynamic force and the formation of fine suspended sediment.Muddy interlayers in the logging curve mainly reflects the characteristics of mudstone, specific performance: the natural potential to shale line;natural gamma was in amplitude ligulate bulge or high fingery amplitude;deep lateral resistivity waslow, declined by more than 50% of the adjacent layer; high interval transit time value; hole diameter serious enlargement or slightly expanding, when the upper and the lower rock were stable shrink diameter thick sandstone, small expanding hole diameter size may also was a reflection of argillaceous interlayers.

3.2 The logging response characteristics of the physical interlayer

Physical interlayerwas due to the change of lithology, diagenesis and caused the reservoir physical propertybecame poor, with a certain porosity and permeability, but did not reach lower limit of the effective thicknessphysical property, impact on the fluid flow.It includes matrix support of fine conglomerate, sandstone and conglomerate, fine grain supported oil sand and silty sandstone, belonging to sediment retention. The shale content of this kind of interlayer was also higher, but the property was more complex.

The character of logging curve of natural potential magnitude was low, slightly return; natural gamma was in the scene of dentate convex; deep lateral resistivity was low, amplitude difference was reduced or zero; interval transit time for the median, situated between mudstone and sandstone; hole diameter slightly expanding phenomenon.

3.3 Quantitative identification of interlayer

(1)Quantitative identification of well logging in the interval

According to well core observation, microscope thin sections and scanning electron microscope (SEM) easier correct identification of mud and physical interlayer, but because of limited well, and logging data was generally. Therefore, by using logging curve recognition interlayer in order to study the the distribution was more practical significance.Well logging curve can well reflect the lithology of reservoir. Logging curves reflect lithology curve are mainly: well diameter, natural potential and natural gamma curve; reflect containing oily curve are mainly: deep and shallow lateral resistivity, micro lateral (microspheres) and the micro electrode curve; reservoir layer and porosity curves reflect mainly: sonic, rock density, neutron porosity curve.The natural gamma ray curve (GR) can reflect the content of shale in the rock. In the case of the known lithology and the fluid in the pore, the sonic transit time (AC) logging can determine the porosity of the rock.The spontaneous potential (SP) only in a few well local intervals can well reflect the characteristics of the reservoir lithology; resistivity logging vertical resolution was higher than that of other kinds of logging curve, which micro electrode curve can well reflect the thickness of the sand layer and the magnitude of the phase of height and magnitude difference also reflects the lithology of the thickness and shale content level, but resistivity curve was mainly affected by the high content of oily; natural gamma curve was a reflection of the optimal curve of lithological response. These well logging curves are the main basis for quantitative identification of well logs.

(2)Establishment of identification criteria

We preferably used a good recognition effect of GR-AC, Rt-AC, porosity - permeability and shale content-porosity curve drawing crossplot and established layer identification chart of the study area. In different layers, logging curves with different range. The following used II sand group as an example, establishedinterlayer identification standard.

1)Identification standard of shale interlayer

Natural gamma value was greater than 70API; formation resistivity was less than 10 /m; porosity was less than 7%; permeability was less than 0.095 Mu m2; shale content was greater than 29%(Fig.1).

2)Physical interlayer identification standard

The time difference of acoustic wave was 210-258 μm/s; the formation resistivity was 10-20Ω/m; the shale content was less than 30%; the permeability was less than 0.933 μm2(Fig.2).

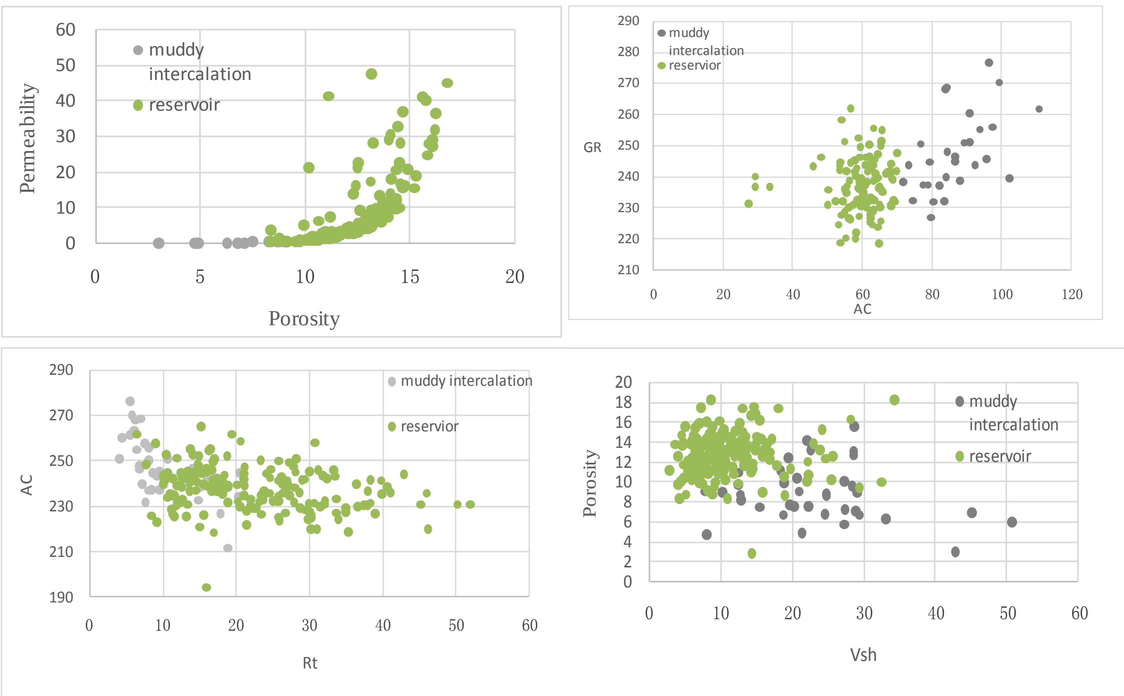
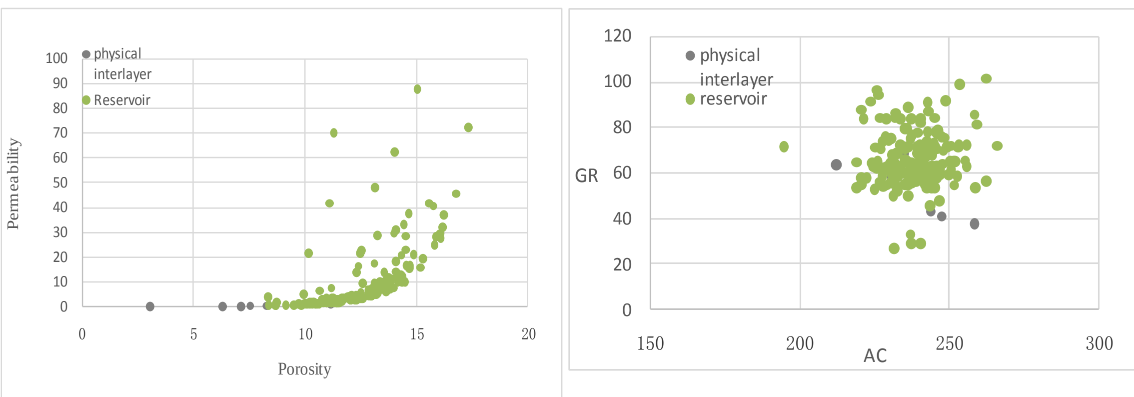


Fig.1.Sand two II sand group shale interlayer identification standard



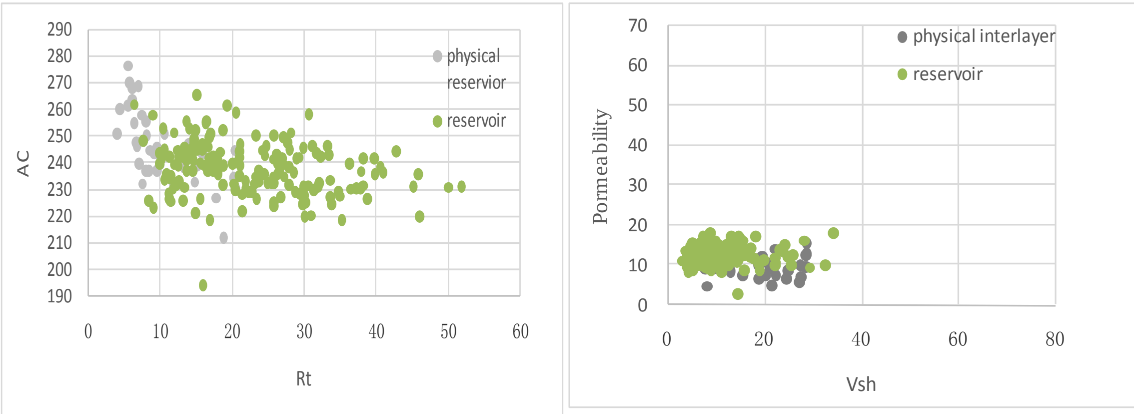


Fig.2.Sand two II sand group physical interlayer identification standard

4. Study on the distribution characteristics of the interlayer

(1)Interval layer plane distribution

In based on the statistics of single well layer thickness, established the sandstone between the sets of single well layer thickness of interlayer database (Table 1), can be obtained by analyzing, the region's longitudinal distribution was more stable layer, which the average thickness of the first level interlayer from 11.8 ~ 16m, the average thickness of the second layer 9.2 to 17m, the average thickness of the third layer 6.8 ~ 19m.

Table 1. The statistics of the growth of interlayer in N74 block Es2

Interlayer category	Interlayer of each unit	Thickness of interlayer (m)		
		Min	Max	Average
I degree	Between Sand Ioil reservoir group and Sand II oil reservoir group	1.6	70.1	11.8
	Between Sand II oil reservoir group and Sand III oil	2.0	39.6	16.0
II degree	Between I Sand group and IISand group	1.7	21.1	9.2
	Between II Sand group and III Sand group	1.6	70.1	11.0
	Between III Sand group and IV Sand group	1.1	53.2	17.0
	Between IV Sand group and V Sand group	1.7	53.2	16.0
	Between V Sand group and VISand group	2.0	39.6	16.0
	Between VI Sand group and VIISand group	2.5	33.0	13.5
III degree	BetweenI-1and I-2	1.5	16.3	6.8
	BetweenI-2 andII-1	1.7	21.1	9.3
	BetweenII-1 andII-2	0.8	70.1	10.2
	BetweenII-2 andIII-1	1.6	70.1	11.8
	BetweenIII-1 andIII-2	1.1	70.1	15.7
	BetweenIII-2 andIII-3	2.0	70.1	15.6
	BetweenIII-3 andIV-1	1.1	53.2	17.4
	BetweenIV-1 andIV-2	1.1	53.2	19.0
	BetweenIV-2 andIV-3	2.3	53.2	17.6
	BetweenIV-2 andV-1	1.7	53.2	16.0
	BetweenV-1 andV-2	1.6	39.6	11.3
	BetweenV-2 andVI-1	2.0	39.6	16.1
	BetweenVI-1 andVI-2	0.8	37.0	14.0
	BetweenVI-2 andVII-1	2.5	33.0	13.5
	BetweenVII-1 andVII-2	0.8	32.1	11.0
	BetweenVII-2 andVII-3	1.9	24.3	8.9

(2) Plane distribution ofintercalation

For the interlayer, in addition to the statistical number of the intercalation and interlayer thickness can be qualitatively described, also need to be characterized by quantitative parameters, this area for intercalation distribution frequency and interlayer distribution density distribution of characterization of interlayers.Interlayer distribution frequency (PK) as per meter reservoir intraformational non penetration number of interlayer, unit (layer / M); interlayer distribution density (DK) per meter storage interformational non permeability interbed thickness unit for (M / M). Based on the subdivision and comparison, the paper makes a comparative analysis on the difference of the inner layer by the detailed description and representation of the inner layer.

Table 2 statistics for the 17 small layer of sand two 7 sand group of the interlayer of the subdivision. And different with the basic stable distribution of the interlayer. In general, the distribution of the interlayer was not stable, and the connectivity between wells was poor.

Table 2.Table of distribution of each small layer

Sublayer	Thinnest (m)	Thickest (m)	Average (m)	The number of interbed	Frequency distribution (Pk)（interbed/m）	Distribution density (Dk)（m/m）	wells
I-1	1	2.3	1.53	3	0.042-0.063 /0.046	0.043-0.096 /0.067	3
I-2	0.46	2.48	1.28	7	0.048-0.068 /0.052	0.023-0.136 /0.068	7
II-1	0.52	1.54	1.07	11	0.045-0.118 /0.065	0.027-0.093 /0.06	10
II-2	0.42	2.18	1.05	25	0.038-0.188 /0.072	0.023-0.249 /0.068	20
III-1	0.54	2.12	1.19	10	0.042-0.188 /0.084	0.034-0.201 /0.081	7
III-2	0.52	2.02	1.1	7	0.056-0.077 /0.067	0.033-0.144 /0.073	7
III-3	0.46	1.52	0.81	6	0.063-0.154 /0.088	0.029-0.109 /0.06	5
IV-1	0.46	2.02	0.97	7	0.048-0.167 /0.09	0.029-0.123 /0.061	4
IV-2	0.92	0.92	0.92	1	0.053	0.048	1
IV-3	0.72	1.6	1.09	4	0.063-0.167 /0.118	0.055-0.2 /0.105	3
V-1	0.5	1.46	0.99	4	0.038-0.059 /0.046	0.023-0.058 /0.044	4
V-2	0.32	1.36	0.75	9	0.04-0.063 /0.053	0.018-0.08 /0.04	9
VI-1	0.39	0.66	0.53	2	0.038-0.071 /0.055	0.015-0.047 /0.031	2

VI-2	0.72	1.06	0.89	2	0.056-0.059 /0.057	0.04-0.062 /0.051	2
VII-1	0.76	1.64	1.67	5	0.059-0.111 /0.081	0.048-0.098 /0.067	4
VII-2	0.44	2.08	1.1	4	0.063-0.1 /0.078	0.031-0.13 /0.08	4
VII-3	1.08	1.08	1.08	1	0.071	0.077	1

Attention:Min-Max/Average

1)Distribution frequency of interlayer

Research draws the in layer interbed distribution frequency contour map, overall level within the interlayer distribution frequency of high value area was approximate continuous banded distribution, intermediate separated by continuous strip low value area which less than 0.1/M. Combined with sandstone thickness isoline map and sedimentary micro facies,north-north east direction banded interlayerwasmulti low value, large thickness of sand body, strong hydrodynamic conditions, source supply sufficient,underwater distributary channel sedimentary center main channel sand body, the south part-western regions and the central in the interlayer of the approximately continuous strip or isolated layer and distribution frequency in high value area of the underwater distributary channel sand body side edge,high value area was water diversion of the river overflowing the sand body, interbed distribution frequency contour map, layer interbed frequency plane changes greatly. In the overall direction of extension wasNE- SW direction.

2)Interlayer distribution density

Study drawn distribution density isoline map within the layer interlayer,high density values in each small interlayer of E_{s2}which greater than 0.2m/m was isolated distribution area.The most well area of each layer was lower area which less than 0.1m/m, the overall extending direction of North East - West to individual small layer due to the influence of other source distribution was not obvious.

5. Reserves calculation

The original reserve calculation was carried out on the basis of the scale of the oil reservoir.This study on the basis of the original block on Calculation of reserves of 17 small layer reserves were detailed calculation, removal in small layer does not contain oil wells around the oil-bearing area, resulting in reduced reserves calculation result.To calculate the reserves of each small layer, the total oil reserves of 436.4×10^4t, 0.1964×10^6m^3 dissolved gas reserves, reserves than before the latest report of the geological reserves of 459.1×10^4t reduced by 22.7×10^4t.

6. Conclusion

(1) According to the porosity and permeability of core analysis, and the response characteristics of well logging curve, this area was divided into 2 types: mud interlayer, physical interlayer.

(2)Area growth stable and larger thickness interlayer, the average thickness of the first interlayer was 11.8 ~ 16m, the average thickness of the second interlayer was9.2 to 17m, the average thickness of the triple layerwas 6.8 ~ 19m. The plane interlayer was unstable distribution.

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