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The study for the calculation methods of the geological reserves of natural gas

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Abstract： - There are many calculation methods of Natural gas geological reserves,such as volumetric method, analogy method, production decline method, material balance method, etc., The volumetric method is suitable for the different stages of exploration and development,with being applied more widely than other methods. This paper takes S0 group of lamadian oilfield for example to taik about how to determine original gas area, effective thickness, average effective porosity, initial gas saturation. In the end, to apply the the formula of volume method to calculate the region natural gas geological reserves.

Keywords： - Gas bearing area; Effective thickness; The original gas saturation; Volumetric method; Geological reserves

I. INTRODUCTION

No matter it is in exploration or development stage, geological reserves has been the focus of the state and enterprises. because reserves are reflected in the study area development potential, is the foundation and the power of future development plan. Calculation of the geological reserves can be a good foundation for the development of oil and gas fields by the volume method. Moreover,it can bring the solid theory basis for the staff to implement plan.

This paper had explained and calculated volume method base on the practical application in detail, so as to enhance scholars' understanding of volumetric method to calculate reserves and provide beneficial help for oil and gas frontier scholars.

The process of calculating gas reserves by volumetric method is same to determine the volume formula parameters,so the process is as follows:

1、To determine the gas-bearing area

2、To determine the effective thickness of the gas reservoir

3、To determine the effective porosity of gas reservoir

4、To determine original gas saturation of gas reservoir

5、To determine gas volume factor under the geological condition

Finally,to use the method of volume formula— $OGIP = 0.01 \times A \times h \times \Phi \times S_g / B_g$ to calculate natural gas geological reserves.

II. DETERMINING GAS-BEARING AREA

1.1 Determination of oil-gas interface

Since gas cap reservoir of S0 group is structural reservoir, the structure has effects on distribution of oil,gas and water（Fig 1） in Lamadian Oilfield,we need to determine the gas boundary according to the oil gas water interface. To apply data of testing oil and testing gas to draw the diagram of oil-gas interface (Fig 2) to determine the oil-gas interface which altitude is -770 meters.

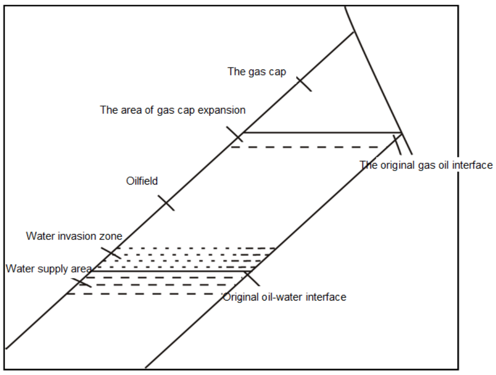

Fig.1： The oil gas water distribution map under ideal condition

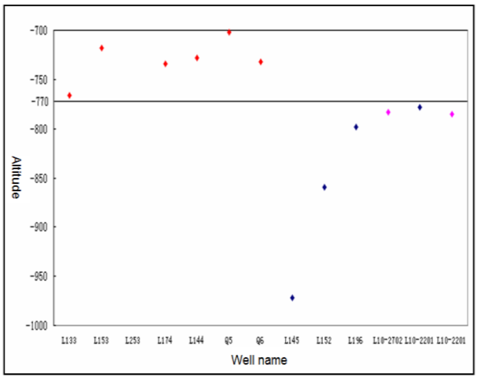

Fig. 2： Oil gas interface diagram in Lamadian Oilfield S0 group

1.2 Determination of gas bearing area

Because S0 group and combination of hydrocarbon bearing in the middle are in the same petroliferous system in Lamadian Oilfield, to make sure the S0 petro interface and lower the top face of the reservoir are in the same height-- the altitude of -770 meters.To project the oil-gas interface onto the top surface structural map of S0 group,then we can determine the S0 group gas bearing area according to the structure contour.So gas bearing area of S0 group pure gas zone is 20.7km^2 and transitional zone's is 6.9 km^2.

III. DETERMINATION OF EFFECTIVE THICKNESS

The north piece of pure gas of S0 group is divided into three gas sand (effective gas sand, one kind of gas sand and two kinds of gas sand) and eight reserve calculation units. The transition zone is lack of core data, so to divide transition zone to two kinds of gas sand according to the standard electrical pure gas region (Table 1).The effective gas sand of piece of pure gas area in Lamadian Oilfield S0 group north is mainly distributed in the lower part, with the effective thickness of 0.5 meters; a kind of gas sand and two kinds of gas sand are mainly distributed in the lower part, their effective thickness is 2.2 meters and 4.7 meters; two kinds of gas sand effective thickness is 3.1 meters in transition zone.

TABLE 1

The Statistical Tables Of Thickness Interpretation Of North In Lamadian Oilfield S0 Group

Type		S01	S02	S03	S0J	S04	S05	S06	S07	S08
Pure gas zone	Effective gas sand (m)	0.0	0.0	0.0	—	0.1	0.1	0.1	0.1	0.1
	One kind of gas sand (m)	0.1	0.1	0.2	—	0.2	0.4	0.4	0.5	0.3
	Two kinds of gas sand (m)	0.1	0.3	0.7	—	0.6	0.6	0.7	0.8	0.9
The transition zone	Two kinds of gas sand (m)	0.2	0.4	0.9	—	0.8	0.5	0.1	0.1	0.1

IV. 3、DETERMINATION OF EFFECTIVE POROSITY

Calculating data of The existing coring well by appling arithmetic average, to determine average effective porosity of effective gas sand of 24.090%, one kind of gas sand average effective porosity of 22.609%, two kinds of gas sand average effective porosity of 21.851% in S0 group. After pressure fitting function (1), corrected effective gas sand for effective porosity of 23.502%, one kind of gas sand of 22.010% and two kinds of 21.246% under the ground.

$$\phi_{undergroud} = -0.7684 + 1.0075 \times \phi_{groud} \qquad \mathrm{R} = 99.9\% \quad (1)$$

In the formula: $\Phi_{undergroud}$—The subsurface porosity, %;

V. DETERMINATION OF THE ORIGINAL GAS SATURATION

Since lacking static information of Lamadian S0 group, to use the datas of L6-J2334 well and L253 well porosity, permeability, oil saturation and water saturation to determine the original gas saturation by curve fitting (2).We can make sure the error value of gas saturation of Various types of reservoir is 1.5% by distillation method. The results of the initial gas saturation of gas sand after correction(Table 2).

$$S_w + S_o = 2.1 - 18.7 \times LogK + 23.3 \times Log\phi \quad R = 96.6\% \qquad (2)$$

In the formula: Sw——water saturation，%；

So——Oil saturation，%；

K——Permeability，10-3μm2；

Φ——Porosity，%。

TABLE 2

Various Types of Reservoir Gas Bearing Saturation in S0 Group

Type	Porosity (%)	Permeability (10-3μm²)	The water saturation after fitting + Oil saturation (%)	The gas saturation (%)	The gas saturation after correction (%)
Effective gas sand	23.502	42.020	59.788	40.212	38.712
One kind of gas sand	22.609	22.825	64.352	35.648	34.148
Two kinds of gas sand	21.851	18.124	65.880	34.120	32.620
The transition zone	21.851	18.124	65.880	34.120	32.620
S0 group (Old datas)	22.000	37.000	60.153	39.847	38.347

VI. CONVERSION VOLUME COEFFICIENT

Volume coefficient of natural gas is the ratio of volume of natural gas under the groud and the volume of surface (3). The volume of natural gas that be brought to the surface will changes more obviously with temperature and pressure decreasing in the ground.So we need to carrect volume factor of natural gas.

$$B_g = \frac{V}{V_{sc}} = \frac{ZTp_{sc}}{T_{sc}p} = Z\frac{(273+t)}{293}\frac{p_{sc}}{p} \qquad (3)$$

In the formula: Vsc、Psc、Tsc——Gas pressure, volume and temperature under the standard condition;

V——The volume of the same quantity of natural gas in the ground;

Z——Gas deviation factor.

According to the national reserves standard[1,2], Take the ground standard temperature of 20℃, the absolute temperature of 293K and take standard pressure of groud of 0.10MPa for standard pressure. The middle of depth of gas reservoir is 865.7m for -715.7m depth, elevation. According to the temperature datas of 4 layers of S0 group's 4 wells and pressure datas of 5 layers of 4 wells, drawing temperature and depth relation chart (Fig 3) and S0 group pressure -- depth curve (Fig 4) in Lamadian Oilfield, to determine the temperature for 39.3℃ in S0 group middle of gas reservoir ,the absolute temperature for 312.3K and gas pressure for 9.52MPa in the gas reservoir central part of elevation of -715.7m.

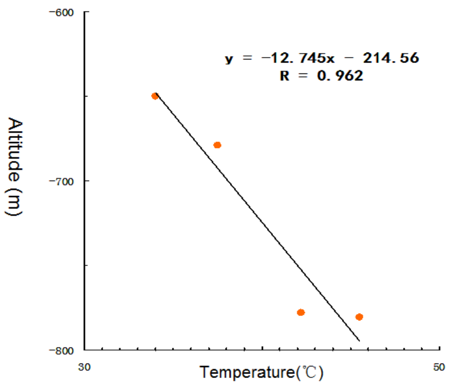

Fig. 3: The temperature curve in S0 group gas reservoir

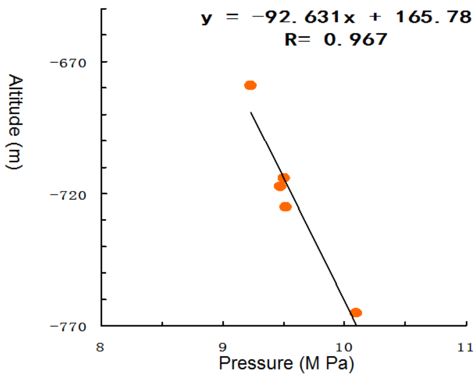

Fig. 4: Pressure curve in S0 group gas reservoir

According to the principle of corresponding state of Fan Dehua[3], the deviation coefficient of real gas and ideal gas is a function of the corresponding pressure and temperature's contract pressure and contrast temperature (4).

$$Z = \frac{V_{actual}}{V_{ideal}} = f\left(P_{pr}, T_{(pr)}\right) \qquad (4)$$

In the formula: Ppr——Pseudo reduced pressure (the ratio of absolute pressure ，P，of gas and pseudo critical pressure—Ppc)，MPa;

Tpr——The pseudo temperature contrast （the ratio of absolute working temperature，T， of gas and pseudo critical temperature—Tpc），K.

According to gas's analysis data of 6 wells, to calculate the percentage of gas's components in S0 group of Lamadian Oilfield (Table 3).Apply Hall-Yarboreμgh method[4] to calculate comparison of temperature (Tpr) 1.62K, comparison of pressure (Ppr) 2.02MPa.Then according to the Equation of deviation coefficient, to calculate the deviation coefficient is 0.867.

TABLE 3

Natural Gas Composition Analysis And Deviation Coefficient Statistics in S0 Group

Block	Horizon	The density of natural gas	The components of natural gas (%)						The pseudo critical temperature (K)	The pseudo critical pressure (MPa)	Comparison of temperature (K)	Comparison of pressure (MPa)	The deviation coefficient
			CH_4	C_2H_6	C_3H_8	C_4H_{10}	N_2	CO_2					
Lamadian	Saertu	0.5815	95.84	0.81	0.50	0.62	1.57	0.22	192	4.72	1.62	2.02	0.867

VII. CALCULATION OF THE GEOLOGICAL RESERVES BY VOLUME METHOD

Formula[5]（5）:

$$OGIP = 0.01 \times A \times h \times \Phi \times S_g / B_g \qquad (5)$$

In the formula: A——Gas bearing area，km^2；

h——The average effective thickness，m；

Φ——The average porosity，%；

Sg——The average initial gas saturation, %；

Bg——The average volume coefficient of natural gas in the groud.

Among them, geological reserves of effective gas sand is 0.97×108m3 in pure gas zone, geological reserves of one kind of gas sand is 3.53×108m^3, geological reserves of two kinds of gas sand is 6.95×108m^3, geological reserves of two kinds of gas sand in transition zone is 1.48×108m^3. The geological reserves of all the gas sand is 12.93×10^8m^3(Table 4).

TABLE 4

The Statistics of Geological Reserves of Effective Gas Sand in Pure Gas Province，Lamadian S0 Group

Reservoir	Block	Sandstone category	Gas bearing area (km^2)	Thickness (m)	Effective porosity (%)	The original gas saturation (%)	Gas temperature (□)	Gas pressure (MPa)	The deviation coefficient	Geological reserves ($108m^3$)
S0 group	The pure gas zone in North block	Effective gas sand	20.7	0.5	23.502	38.712	39.3	9.52	0.867	0.97
S0 group	The pure gas zone in North block	One kind of gas sand	20.7	2.2	22.010	34.148	39.3	9.52	0.867	3.53
S0 group	The pure gas zone in North block	Two kinds of gas sand	20.7	4.7	21.246	32.620	39.3	9.52	0.867	6.95
S0 group	The transition zone in North block	Two kinds of gas sand	6.9	3.1	21.246	32.620	39.3	9.52	0.867	1.48

VIII. CONCLUSION

The volumetric method to calculate the reserves of natural gas is suitable for different exploration and development stages. The method is the preferred method for estimation of reserves of oil and gas field.

Volumetric method which uses the data of development of static to calculate reserves can work out different types of sand body geological reserves.

The volumetric method to calculate the reserves may have a greater error and can't accurately estimate the geological reserves in the blocks which structure are complex, reservoir distribution and location are non-uniform.

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