CSCanada
Advances in Petroleum Exploration and Development
Vol. 11, No. 2, 2016, pp. 75-79
DOI:10.3968/8583

ISSN 1925-542X [Print]
ISSN 1925-5438 [Online]
www.cscanada.net
www.cscanada.org

The Discussion of the B603 Block's Supplement Development Scheme

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Received 28 May 2016; accepted 24 June 2016
Published online 26 June 2016

Abstract

To B603 block, the main strata is Guantao group of four sand groups, the reservoir buried deep is 1,004-1,067 m, reservoir lithology is mainly siltstone, reservoir belongs to high porosity and high permeability, and reservoir type is mainly structural lithological reservoir. According to the design of the previous adjustment plan, four wells were drilled in 2010. In order to further improve the producing degree of reserves and recovery factor, the previous adjustment plan was improved. North District, where well control is poor, continued to be expanded to improve the producing degree. And southern district continued to improve well network and enhance ultimate recovery factor.

Key words: Supplement development; Well network; Enhance recovery factor

Chen, L., Ding, L., & Xie, X. Q. (2016). The discussion of the B603 block's supplement development scheme. *Advances in Petroleum Exploration and Development*, *11*(2), 75-79. Available from: URL: http://www.cscanada.net/index.php/aped/article/view/8583
DOI: http://dx.doi.org/10.3968/8583

INTRODUCTION

Oil production test was implemented in April 1983 in B603 block, and 3 testing wells obtained industrial oil flowing. It experienced two development stages, the oil production testing and rolling capacity. It's producing by natural energy now.

According to the adjustment scheme of 2010, 4 new wells (B601-X1, B603-X9, B603-X10 and B603-X11) had been drilled and produced in 2010. Scheme, those wells main produced on Ng46 layer, initial oil production is 6.3 tons, the average composite water cut is 32%. Now oil production is 7.3 tons, average water cut is 43%, cumulative oil is 3,406 tons, accumulated water is 2,024 tons, the overall implementation's effect is better. But there are still several problems need to be improved[1-3]:

(a) Need 1 injection well and supplement energy for the reservoir as soon as possible.

(b) Need to implement pressure and dynamic monitoring of the 4 new wells, in order to understand the oil reservoir to more, and improve the scheme and rolling extension.

(c) According to the results of new seismic interpretation,, there was further rolling development potential near the northern B601-X1 area and southern B603-X11, it should be reflected in the supplement development scheme.

1. ECONOMIC POLICIES

1.1 Development Mode

According to the research of the geological and well test and production test data, there was not original gas cap and edge-bottom water. So that the reservoir is mainly for the elastic displacement and dissolved gas drive.

1.1.1 The Evaluation of Elastic Energy

According to the elastic displacement closed material balance equation for calculating elastic phase recovery (Formula 1)[4-5].

$$E_R = C_t \frac{(P_i - P_b)}{1 + C_0(P_i - P_b)}. \tag{1}$$

In Formula (1):

E_R—Elastic recovery, f;
C_t—Composite compressibility, 10^{-4} 1/MPa;
P_i—Original formation pressure, MPa;
P_b—Saturation pressure, MPa;
C_o—The compressibility of crude oil, 10^{-4} 1/MPa.

The elastic recovery factor was 1.57% according to Formula (1).

1.1.2 Dissolved Gas Drive Energy Evaluation

When oil field development to dry up pressure, dissolved gas drive mining will come to an end. Take the formation dry up pressure is 80% of the saturation pressure, the solution gas drive recovery factor can be calculated with Formula 2[6-8].

$$E_R = 0.2126\left[\frac{\phi(1-S_{wi})}{B_{ob}}\right]^{0.1611}\left(\frac{\overline{K}}{\mu_{ob}}\right)^{0.0979}(S_{wi})^{0.3722}\left(\frac{P_b}{P_a}\right)^{0.1741}. \quad (2)$$

In Formula (2):

ϕ—Effective porosity, f;

S_{wi}—Irreducible water saturation, f;

B_{ob}—The volume coefficient of saturated pressure;

K—Air permeability, μm^2;

μ_{ob}—The Crude oil viscosity of saturated pressure, mPa·s;

P_b—Saturated pressure, MPa;

P_a—Abandonment pressure, MPa.

Through calculation, the dissolved gas drive recovery factor was 6.48%.

The elastic and dissolved gas drive recovery factor was 8.05%. Therefore, only rely on natural depletion, ultimate recovery was low, and energy should be supplement timely.

1.2 Development Series of Strata

In B603 Ng4 there were three main oil-bearing layers, which were thin, small, low reserves abundance and do not have the development material basis of subdivided formation. Therefore, B603 was development using one set of series.

1.3 Well Pattern and Well Spacing

For the geological characteristics of B603, inverse seven and five point's well pattern was designed. Through the numerical simulation scheme index prediction, the development effect of five point well pattern was better. Through calculation, the reasonable well spacing value is about 300 m.

1.4 Single Well Production Capacity

1.4.1 Single Well Daily Oil Production

There was no flow pressure data in B603, so flowing pressure was converted with working fluid level data. The average productivity index of 2 wells was 1.63 t/d·MPa and specific productivity index was 0.85 t/d·MPa·m in the initial stage of production.

The production capacity of new single well was 5.2 t/d when production pressure differential was 3.0 MPa, perforated thickness was 2.4 m, and dimensionless oil recovery index was 0.85.

Combining with the current development status, the oil production of new single well oil was 5.0 t/d, and that of old single well oil was 3.0 t/d.

1.4.2 Single Well Daily Fluid Production

According to the relationship between dimensionless oil/fluid recovery index and WCT, the largest single well produced fluid was 21.7-59.3 m^3/d, when WCT was 90%, dimensionless fluid recovery index was 3.9, production pressure differential was 3.0 MPa, and perforated thickness was 2-6 m.

1.4.3 Largest Water Injection Capacity of Single Well

(a) Theory water injectivity index calculation (Formula 3)

$$I_w = \frac{0.236kh}{u\lg\frac{r_e}{r_w}}. \quad (3)$$

In Formula (3):

I_w—Theory water injectivity index;

k—Effective permeability, 10^{-3} um^2;

h—Effective thickness, m;

u—The viscosity of groundwater, mPa·s;

r_e—Supply oil radius, m;

r_w—Hole radius, m.

Through calculation, the results was I_w=10.7 m^3/MPa·d.

(b) The water injectivity index of adjacent block reservoir

According to the statistics, the actual calculating water injectivity index was 7.7-8.2 m^3/d·MPa, and start-up pressure was 2.5 MPa in Lindong reservoir.

(c) The largest wellhead injection pressure calculation

According to fracture pressure = largest wellhead injection pressure -Wellbore frictional resistance loss+Static water pressure, when the biggest safety pressure was 19.6 MPa, wellbore frictional resistance loss was 2 MPa, Static water pressure was 10.3 MPa, the largest wellhead injection pressure was 11.3 MPa.

(d) Single well water injection calculation

The formulas were as follows:

$$Q_W = I\cdot\Delta P. \quad (4)$$

ΔP—Water injection pressure differential, MPa.

Through calculation, the largest water injection pressure differential was 7.3 MPa, and the biggest single well water injection was 56.2-78.1 m^3/d.

2. THE SUPPLEMENT DEVELOPMENT SCHEME

2.1 Design Principles

The supplement scheme is based on the implementation of the adjustment plan, according to the following principles:

(a) Optimizing deployment should base on the design and implementation of the adjustment scheme;

(b) According to well condition, use the wells of the edge of the reservoir injection, and the wells of the middle-high of the reservoir production;

(c) In the main production areas, deploy new well and improve well network, to improve the producing degree of reserves;

(d) Deployment overall and implement in batch;

(e) Use the new technology of prevent sand to improve the utilization rate of oil and water wells.

2.2 Scheme Design

The perfect design is mainly aimed at the area south of Ng4 layer. Its area is 3.2 km^2, and reserves is 152.4×10^4 t. According to the development status of the reservoir, the remaining oil distribution, potential economic parameters and adjustment technology research, two supplement development scheme s were designed, based on the adjustment plan.

2.2.1 No. 1 Scheme

Design ideas: Area pattern water-flooding, drilling new injection wells to supplement the formation energy and drilling new wells to perfect the well network.

The well pattern is irregular inverted five spot and well space is about 300 m. The total number of wells is 21, including 15 oil wells and 6 injection wells, 3 new wells (1 injection well), 5 new injection wells. The injection production ratio is 2.5, annual oil is 1.62×10^4 t, oil production rate is 1.1%, single well control reserves is 9.6×10^4 t/well, single well water injection is 19.8 m^3/d, and the annual water injection rate is 3.6×10^4 m^3.

2.2.2 No. 2 Scheme

Design ideas: Product in central, not drill new injection well in edge, and drill new wells in a local to improve pattern.

The well pattern is irregular inverted five spot and well space is about 300 m. total number of wells is 15, including 12 oil wells and 3 injection wells, 2 new wells, no injection wells, the injection or production ratio is 4.0, annual oil is 1.2×10^4 t, oil production rate is 0.8%, single well control reserves is 12.0×10^4 t/well, single well water injection is 29.3 m^3/d, and the annual water injection rate is 2.6×10^4 m^3.

2.3 Index Forecast

(a) The rate of comprehensive production rate is estimated by 300 days.

(b) Production decline rate: According to productivity evaluation, the initial production of new wells is 5.0 t/d. Because the new wells are deployed at the big thickness and high structural parts, the yield of the first year does not decrease. Considering the recent decline in production wells and the seepage characteristics of oil reservoir, the first few years of decline rate is 10%.

(c) Water injection: According to the capacity and injection production ratio, initial injection production ratio is 1.1, the early single well water injection is about 20 m^3/d, the initial water decreasing rate is 5%. With the increase of formation energy, water flooding difficulty will increase, and the water injection decreasing rate is 10% in a few followed years. That is 5% in the latter because the efficiency of water injection may be improved.

(d) Water cut rising rate: According to the current situation of production of the block, the initial water cut is 36%. Considering the water status of recent production wells. The water cut rising rate of the first 3 years is 2%. Combining with the percolation characteristics of reservoir, after a few years, water cut rising rate will expand to about 5%-10%. After water cut is higher than 60%, water plugging measures will be implemented, and the water cut rising will slow, whose value is 5%.

According to the forecast, at the end of fifteenth, the cumulative oil production of No.1 Scheme is 22×10^4 t, the recovery level is 14.5%, and water cut is 68.5%. For No.2 Scheme, the cumulative oil production is 18.6×10^4 t, the recovery level is 12.2%, and water cut is 68.5%.

2.4 Scheme Optimization

Due to the current formation pressure drop and some wells have been shut in for inadequate fluid, in order to improve the development effect, injection water should be implemented to supplement the formation energy at once.

No. 2 Scheme: big single control reserves, no-drilling new injection wells, less new drilling, low cost, good economic benefit.

Therefore, the No. 2 scheme is recommended for implementation.

3. IMPLEMENTATION PROPOSALS

3.1 New Wells

The scheme deploys 2 new oil wells. Well 1 should be drilled first, and then wells 2 (Figure 1).

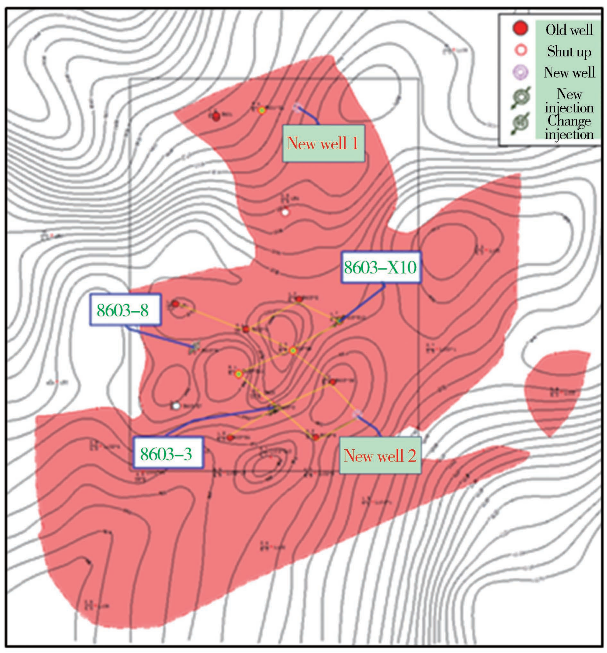

Figure 1
Schematic Diagram of B603 Block

(a) According to the seismic inversion reservoir prediction results, the sand body development is good, located in the northern part of the B601 well area. Especially, the sand body development of eastern part of B601-X1 is more thicker than B601-X1. So 1 new oil well is deployed here, about 300 meters from the east of B601-X1 (As shown in Figure 2).

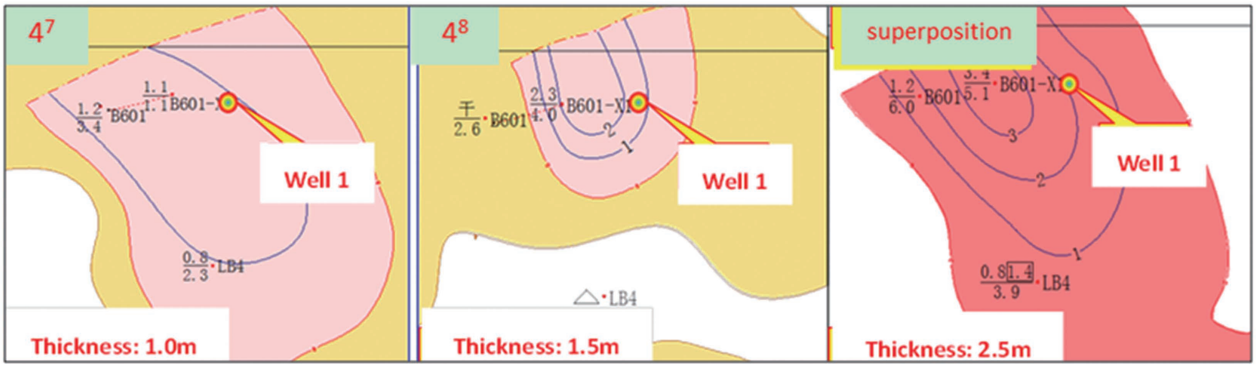

Figure 2
Well 1 Oil Reservoir Drilling Situation

Well 1 is located in the structure of the high position, and there are sand body display in layer Ng48 and Ng47. The inversion section shows that the sand body reaction in this area is better than that of B601-X1. Adjacent wells B601-X1 and B601 are all shot to open Ng47, and the production situation is good. Initial production capacity is expected to be 5.0 t/d.

(b) According to the results of seismic inversion to reservoir prediction, in B603-5 and B603-X6 southeast of the block, the sand is thick too. Especially NG46 and NG48 are distributed at the premises of contiguous here. So, 1 new oil well is deployed where is about 300 meters from B601-5 and B601-X6 (As shown in Figure 3). Initial production capacity is expected to be 8.0 t/d.

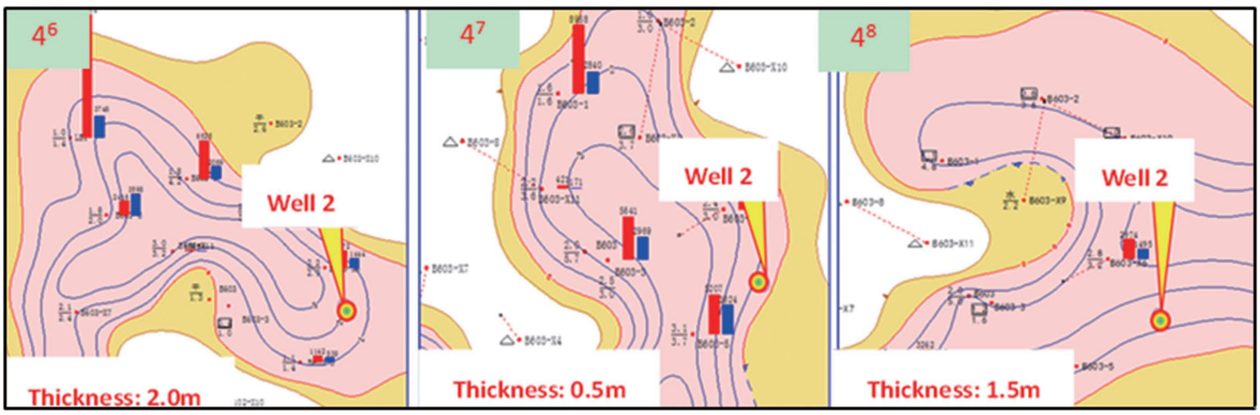

Figure 3
Well 1 Oil Reservoir Drilling Situation

3.2 Injection Wells

(a) B603-8 will turn into water injection preferentially, and then is B603-3. After B603-8 inject to Ng46, the peripheral well Lb1 (Ng46), B603-1(Ng46 and Ng47), and B603-X11(Ng46 and Ng47) is expected to work. The daily injection rate is expected to be 29.3 m^3/d and annual injection is expected to be 8,790 m^3.

(b) After B603-3 inject to Ng47, the peripheral well B603-5 (Ng46 and Ng47), B603-X6 (Ng46, Ng47 and Ng48), and B603-X11(Ng46 and Ng47) is expected to work. The daily injection rate is expected to be 29.3m^3/d and annual injection is expected to be 8,790 m^3.

3.3 Old Oil Wells

According to the current situation and previous research results, B603-8 and B603-3 need to turn into water injection. B601-X1, B603-1 and B603-X11 will need supplementary perforation, and other wells maintain production status.

CONCLUSION

(a) This supplement development scheme is improved based on the implementation of prior adjustment scheme. The development mode and production capacity are further optimizated. After the implementation of the project, the recovery factor is expected to enhance 1%-2%.

(b) In this supplement development scheme, the well spacing is about 300 m, and well net is irregular inverted five spot. It has 2 new wells, 3 injection wells, and no new drilling well. Compared with the adjustment scheme, it mainly uses the old wells, has no-drilling new wells, has too smaller invest, more practical and economic benefit.

(c) At the end of 15 years, cumulative fluid production will increase 2.8×10^4 t, the cumulative oil output will increase 1.5×10^4 t and the recovery factor will increase 1%.

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