PROCEEDINGS
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STUDY OF HYDRAULIC FRACTURING STIMULATION AS PROVEN NOVEL TREATMENT IN REVEALING JABUNG OIL CAPACITY

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Abstract

Overall Jabung Block demonstrated considerably high success ratio of finding economic hydrocarbon since operated by PetroChina on 2002. Oil and gas have been produced coupled with more discoveries (Basement, NEB LTAF, and NEB GUF) within the Jabung Block provided more challenging of future hydrocarbon assesment to both tight sand reservoir condition and significant high CO_2 content. Exploration phase of NEB area had only assumed oil reservoir potential only developed in the northern part before oil discovery was ever proven in southern area. As part of continuous exploration effort PetroChina drilled NEB EXT-1 exploration well that located in down-dip of NEB southern area on 2017, which will be a key well to prove the extension of NEB oil rim. As predicted, Drill Stem Test (DST) showed 38 BOPD intermittent oil flowed on 128/64 choke DST-2 from Lower Talang Akar Formation with 0% CO_2 content, opening the validity of NEB oil rim extension area. Combining DST result with the pressure build-up analysis conclude the potential zone do not have significant lithological properties or classify as tight reservoir (5 mD permeability; 0.08 (STB/D)/Psia Productivity Index (PI)) but possess the promising formation pressure up to 2314 Psi. Hydraulic fracturing stimulation has been chosen to deal with reservoir properties limitation in NEB EXT-1 well. Integration of geology, geophysical and reservoir modeling data is required to propose the fracturing model. Over than 44 mD permeability appears in DST-2 virgin zone, productivity index increases to 4.10 (STB/D)/Psia and reservoir rate picked to 101.5 BOPD after the course. All in all, this case study provides the way how hydraulic fracturing could succeed to impact tight oil reservoir in NEB Area focusing in NEB EXT-1well and how the program will reveal hidden prospect area surround NEB (i.e.: Tandur, Mamora, West Bejo prospect) as part of Jabung upside potential.

Introduction

The hydraulic fracturing program has been applied at sandstone Lower Talang Akar Formation (LTAF) in NEB Extension-1 (NEB EXT-1) exploration well. Based on drilling data LTAF (primary objective) was tagged at 5402' and Gumai Formation (GUF) (secondary objective) at 2987' MD/TVD respectively. The total depth of the well is 5797' MD/ 5796.4' TVD (- 5761' SS) with 31 days drilling formation. NEB EXT-1 is located about 1 kilometer to the southwest of NEB Field as one of Jabung big contributing field and suspected have quite similarity reservoir characteristic with proven zone at Ripah Field (Figure 1). The Ripah-3 well has been tested as oil well producers from multiple LTAF reservoirs by flowing 354 BOPD from DST#2. NEB Extension structure become very promising prospect because the structure considered as separated structure that located lower than NEB structure, higher from Ripah structure (Figure 3) and surrounded by active produced field such as NEB Field, Gemah Field, and Ripah Field (Figure 1).

Data and Method

To conduct the interpretation and program, all the datasets in this study was derived by PetroChina International Jabung Ltd. The data consists of drilling parameters, mud log, wireline log (including MRIL log), production parameter, basic reservoir engineering parameter, testing result and history. This study used one (1) onshore exploration wells from the Jabung Block - South Sumatra Basin as our pilot project.

For geological assessment we have conducted two preliminary analysis which are wireline logging interpretation and petrophysical

analysis as our preliminarily data in determining reservoir properties such as porosity and permeability. Furthermore, we also created well to well correlation to look over the hydrocarbon fluid distribution around the prospect zone and cross-plotting formation pressure data to ensure current fluid contact trend (Figure 2). The integration through qualitative and quantitative approach was expected to provide good quality control to measure the accuracy of reservoir prospect.

For hydraulic fracturing treatment, we have applied conventional fracturing processes with P-3D and or PKN fracturing geometry method as an effort to enhance low permeability prospect zone in LTAF.

Result and Discussion

Preliminary Reservoir Indication

The determination of the hydraulic fracturing zone begins by observing existing geological data which can reflect the lithological change, properties and fluid content from each existing potential interval. This data integration will be a reference in determining the treatment model of hydraulic fracturing program that will be carried out in NEB EXT-1.

1. **Mudlog Data**
   Cuttings sampling and gases detecting from the well bore starts from surface to final total depth. Based on the mud log data there are total two (2) interesting reservoir zones that indicated from gas while drilling, drilling break, and oil shows ranging from poor to trace oil show within LTAF. The detailed lithology and supporting remark described as Figure 3.

2. **Sidewall Core Data**
   Total 5 points of rotary sidewall cores were attempted at LTAF interval within 5411'-5655' MD. 5 cores were recovered with the recovery is 100% and mostly dominated by sandstone. Detailed side wall cores description for each section is shown as Figure 4.

3. **Wireline Logging Interpretation Data**
   Totally five (5) zones were interpreted to be potential zones in NEB EXT-1, three (3) of them has been found in LTAF. Integrated interpretation was conducted by the utilization of compact drilling data and wireline logging package to determine each LTAF reservoir properties. The detail petrophysical interpretations were shown as Figure 5.

4. **DST Data**
   There are three (3) testing interval that covered NEB EXT-1 LTAF interest zone. DST #1 at 5534' – 5548' MD, DST #2 5504' – 5512' MD and DST #3 at 5416' – 5421' MD. Herewith the detail of testing remarks as shown in Figure 6.

   The objectives of the NEB EXT-1 testing programs are:
   - To convince HC potential of more layers from LTAF as primary target (UTAF and GUF as secondary).
   - To prove oil capacity in LTAF sands as per previous geological model. If its work, will be another prospective oil potential in between Northeast Betara (NEB) structure (i.e.: Tandur, Mamora, West Bejo prospect).
   - To ensure fluid content, type and deliverability/ rate.
   - To convince the volume of HC in NEB structure area.

Program Treatment

1. **Pre Fracturing Condition**
   Based on the intermittent flow results at the 5534' – 5548' MD perforation interval (DST #1) and 5504' – 5512' MD (DST#2), PBU test with Pi 2314 Psia K 5.03 mD, Skin 0.9. From high Pr data and skin showing good condition but have low permeability impacted inhibit oil flow rate to wellbore. This is the basis of consideration to conduct hydraulic treatment.

   Hydraulic fracturing treatments are used to improve the low permeability values 4-5 mD, to increase the productivity index, and to form a conductive new channel, so that hydrocarbons flow more easily from the productive formation into the wellbore and

will increase current productivity of NEB EXT-1 well (Figure 8).

2. Post Fracturing Condition

LTAF DST #2 zones is thin sand with 10 ft thickness and permeability about 18 mD and formation pressure about 1686 psi. It was confirmed that the oil producer zone where the well was flowing intermittent 100% oil 36 API. It was suspected the formation damage while drilling has blocked the formation conductivity to well bore. This condition has been confirmed as shown during performing step rate test where the pressure was higher than fracturing pressure at low rate 1 bpm 2363 psi; 2 bpm 2583 psi; 3 bpm 2646 psi; 4.2 bpm 2750 psi.

Refer to the mini fracturing analysis result where mini fracturing has been done at 16 bpm but only give pressure about 2,400 psi, then fracturing design has been finalized using that new confirmed data where fracturing gradient is 0.64 psi/ft, Young's Modulus about 3.24 MMpsi, critical stress about 110 psi and from mini fracturing pressure decline analysis the leak of is about 0.02 (ft/sqrt(min)) and spurt loss is on the same about 0.005 (gal/100ft^2).

The final treatment design is to pump about 50 bbl slug and flushing with about 130 bbl fracturing fluid prior continue pumping 40k lbs proppant on 650 bbl fracturing fluid on proppant ramping design. Main fracturing has been done in two times, when the first job was early screen out at third stage on total proppant pumped about 9.5k lbs the second job was done after reversing out all the excessive proppant inside string and got pack after pumping about 28k lbs propane on displacement step about 16 bbl of 34 bbl total displacement, is has been stop due to the pressure was increase on annulus up to 1,640 psi. CT has been run to clean out excessive proppant inside sting after fail to reversing out due to limitation pressure on annulus, maximum pressure 1,750 psi and string has to be punched to make a hole for reversing out prior pulling out of hole the packer (Figure 8).

Conclusion

1. The oil discovery in the LTAF zone at NEB EXT-1 both by testing and fracturing program successfully open the opportunity to revive the others prospect area (i.e.: Tandur, Mamora, West Bejo prospect) with the similar geological setting around NEB EXT-1 (Figure 9) and able to prove NEB oil rim extension area which has been interpreted so far.

2. Geological data integration which can reflect the lithological change, properties and fluid content act as a very fundamental element to determine the treatment model of hydraulic fracturing program.

3. Type of completion can be major issue due to the major impact during hydraulic fracturing, especially during main frac.

4. An effort to add some exploration well (key wells) in the nearest prospect structure is needed to be able to build a comprehensive understanding of the geological model for the activation of Jabung upside potential development.

Refrences

Gidley, J.L., Holditch, S.A., Nierode, D.E. et al.1989. SPE Monograph Series, Recent Advances in Hydraulic Fracturing.

King, George E. 2013. Well Integrity: Hydraulic Fracturing and Well Construction – What Are the Factual Risks?

Pradipta, Adrianus., Wirawan, Alvin., Luciawaty, Mery., 2018. Impact of Completion Type for Hydraulic Fracturing Operation in Tight Sand Reservoir, Offshore North West Java. IPA Proceedings No. IPA18-232-E, Indonesia.

Veatch Jr., R.W. and Moschovidis, Z.A. 1986. SPE-14085-MS. An Overview of Recent Advances in Hydraulic Fracturing Technology.

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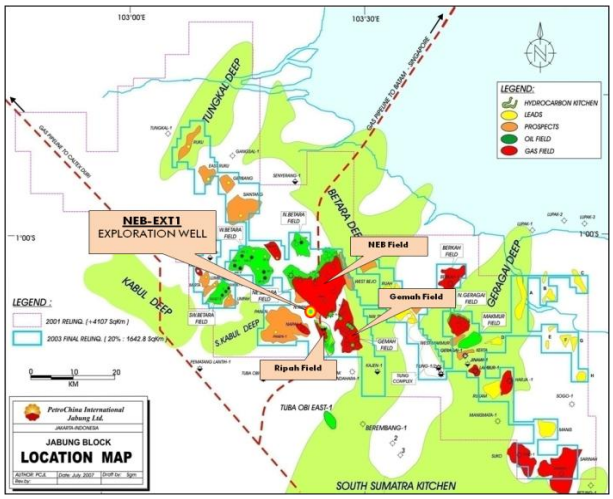


Figure 1. NEB EXT-1 Well Location Map

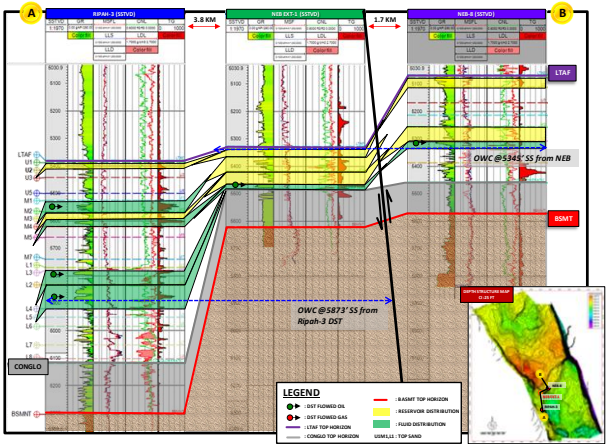


Figure 2. Well to well Correlation through Ripah and NEB Field, Jabung Block

Depth Interval (ft MD)	Lithology	Remark
5190 - 5370	**SANDSTONE,** grey to light grey, clear to translucent, white to off white, occasionally brownish grey, black, friable to moderately hard, fine to medium grained, loose quartz, sub angular to sub rounded, locally angular, poorly sorted, moderately cemented with calcareous cement, trace very fine grained glauconitic nodule, trace fossil foram, poor to fair visible intra-granular porosity, nil to trace gas show.	**@ 5276' MD/TVD** (TG: 400.1 unit) <2 % bright yellow fluorescent, very slow bluish white fluorescent streaming crush cut, no residual ring, no stain, no odor, nil to trace gas show.
5370 - 5560	**SANDSTONE,** grey to light grey, clear to translucent, white to off white, occasionally brownish grey, black, friable to moderately hard, fine to medium grained, loose quartz, sub angular to sub rounded, locally angular, poorly sorted, moderately cemented with calcareous cement, trace very fine grained glauconite nodule, trace fossil foram, poor to fair visible intra-granular porosity, nil to trace gas show.	**@ 5418' MD/TVD** (TG: 318.6 unit) 1-3 % bright yellow fluorescent, no streaming crush cut, no residual ring, no stain, no odor, nil to trace gas show. **@ 5504' MD/TVD** (TG: 400.1 unit) <5 % bright yellow fluorescent, very slow bluish white fluorescent streaming crush cut, light milky white fluorescent residual ring, light straw stain, no odor, trace to poor gas show.

Figure 3. Lithology Description and Hydrocarbon Shows Remark

Core No.	Depth ft MD	Oil show	Description
3.	5560	-	**Medium grained sandstone**, dark to medium gray, moderately hard to hard, sub rounded, moderately sorted, fair visible porosity.
4.	5546	-	**Fine to medium grained sandstone**, dark to medium gray, moderately hard to hard, sub angular, poorly sorted, dominantly quartz, poor visible porosity.
5.	5540	-	**Medium grained sandstone**, dark to medium gray, moderately hard to hard, sub angular to sub rounded, moderately sorted, dominantly quartz, fair visible porosity.
6.	5512	Oil show, 10% bright yellow fluorescent, slow streaming cut, pale yellow fluorescent residual ring, light straw stain, weak odor, trace oil show.	**Fine to very fine grained sandstone**, medium to light gray, brownish gray, moderately hard to hard, sub rounded, moderately sorted, occasionally lose quartz, no visible porosity.
7.	5510	Oil show, 5% bright yellow fluorescent, instantly diffuse, pale yellow fluorescent residual ring, light straw stain, weak odor, trace oil show.	**Fine to medium grained sandstone**, medium to light gray, moderately hard to hard, sub rounded, moderately sorted, occasionally lose quartz, no visible porosity.

Figure 4. Rotary Sidewall core description in LTAF section

Figure 5. Summary of petrophysical analysis in NEB EXT-1 well

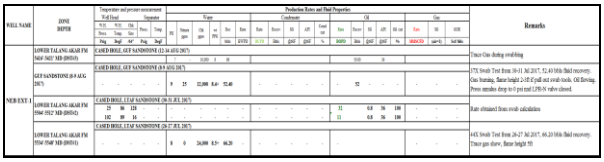
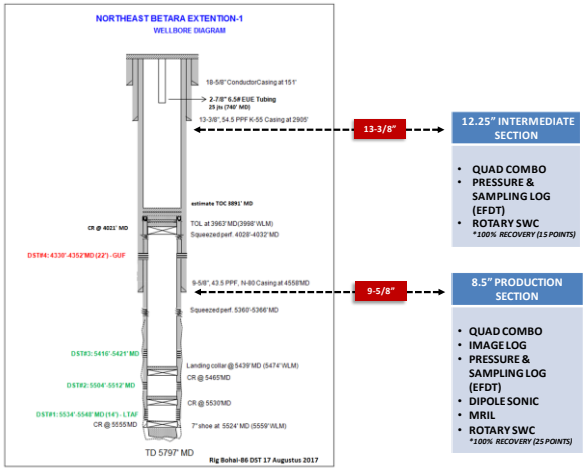
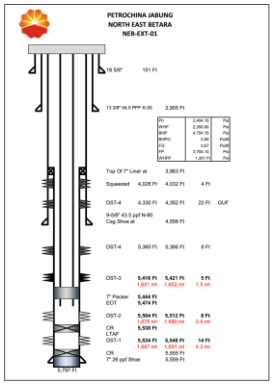


Figure 6. Detail Testing Summary

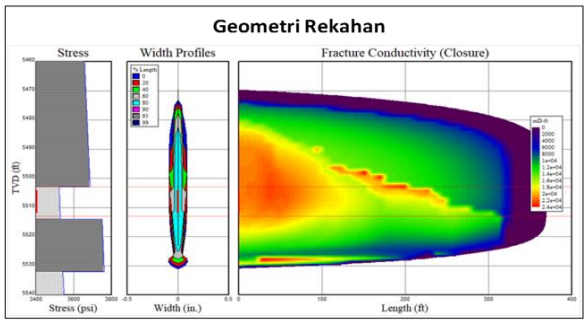




Casing Size	9 5/8" N80	43.5 ppf
Casing Depth	4,558	Ft
Casing Liner Size	7" L80	26 ppf
Top of Liner	3963	Ft
Casing Shoe	5,559	Ft
Bridge Plug	5,530	Ft
Perforation	5,504 Ft MD	5,512 Ft MD
Perforation size	4 ½"	
Perforation density	12 spf	
Drill Pipe Size	3 ½"	9.3 ppf
End of Depth	5474 m kb	
Packer	7"	23–29 ppf
Packer Depth	5,444	Ft
Zone	LTAF-B	Sandstone
Formation	TAF	Talang Akar
Formation Thickness	8	Ft MD
Porosity	19	%
Permeability	18	mD
Reservoir Pressure	1682	Psi
Res Temperature	186	deg F
Density	2.35 gm/cc3	Log
Drainage Radius	600	ft

Figure 7. Pre Program Wellbore Diagram and Logging Acquisition (top) and Post Program Wellbore Diagram (bottom)

WHILE FRACTURING :



Paramater	Data	Unit
Panjang Rekahan (X_f)	321.24	ft
Lebar Rekahan (W_f)	0.68161	inch
Tinggi Rekahan Pay Zone (H_f)	35.31	ft
Dimensionless Conductivity (Fcd)	3.4479	
Fracture Conductivity (Wkf)	15506	mdft
Avg. Fracture Permeability	1457.6	mD

Figure 8. Actual Hydraulic Fracturing Model in NEB EXT-1

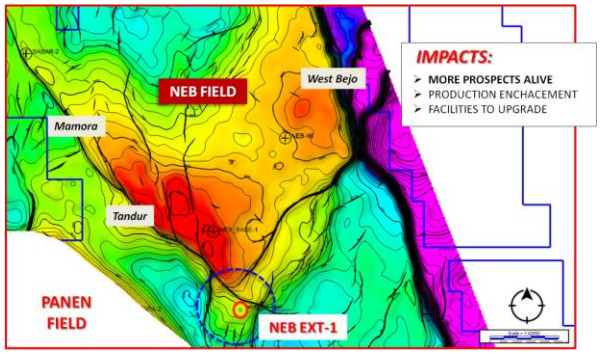


Figure 9. Impact Expectations of Successfully NEB EXT-1 Fracturing Program