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Well Test Analysis in Fracturing Well Ogan Field

WELL TEST ANALYSIS IN FRACTURING WELL OGAN FIELD

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Abstract

Analysis were performed on data acquired during dedicated operations called well test. Well test analysis were used to determine a reservoir model, reservoir development and recommendation to perform stimulation job or fracturing job in a damage reservoir. In Ogan field, several layers are known as tight reservoir its describe from log interpretation and low production index. In this case we used well test analysis to determine reservoir model after fracturing job perform in a tight reservoir layer.

Several wells in OGAN field were produced from tight layer describe from low production test after perforated. Well test performed to obtain reservoir characteristic before well intervention, the results are positive skin, low permeability and low productivity index, these results of well test are used to initiated fracturing job in this well.

After fracturing job, production test shows production rate was not increase than before, then well test performed again to analyze the changes of reservoir characteristic after fracturing job done in OGN XX. In this paper derives well testing analysis to determine the causes of production rate below as expected.

Keywords: Well Test, Stimulation, Fracturing, Lifting Opitimization

1. Introduction

Ogan field is one of largest oil production in Pertamina EP Asset 2. Produce from mostly in talang akar formation, each of layers has their own characteristics. Production increase mostly from fracturing and stimulation activities. Geographically this structure is located in the province of South Sumatra, 35 kilometer to the east of Prabumulih city center with an area of approximately 28 km^2.

Ogan Field has substantial reserves (Oil 54.6 Mstb (P1) & 5.75 Mstb (P2) and Gas 53 Bscf from non – associated and associated gas.

Reservoirs in Ogan field some layer known as tight layers, however it has potential oil describe after these layers had perforated and start to produce despite it was low productivity index, these layers has proven potential oil.

Potential oil layers in Ogan Field are a0, a01, a1, a03b, A, and B. Nowdays, major production is from tight layer, after fracturing these layers had given a good productivity index and increased almost 70% of total production in Ogan Field.

Typical oil in Ogan field is paraffinic and heavy oil with average API 25, then all well produce oil with artificial lift. Gas lift and ESP are major use as artificial lift in Ogan Field, for the well with low influx reservoir or after workover done, gas lift was used to produce oil. The source gas for gas lift itself is form a single well with produce non associated gas from Baturaja formation.

When well test analysis define production capacity allowed produce >200blpd then we recommend to convert lifting from gas lift to ESP.

The initial total oil in place (OOIP) of Ogan Field Talang Akar Formation is around 54.6 MMSTB and the total initial gas in place (OGIP) of Batu Raja Formation is around 44 BSCF. Cumulative oil production until 2017 at the Talang Akar Formation 12.61 MMSTB, Talang Akar remaining reserves amounted to 7.68 MMSTB and Gp amounted to 25.44 BSCF.

Production Ogan Field reached three times peak production, first at 1811 BOPD in 1982, second 1977 Bopd 1999 and last 3174 bopd 2014, the last peak production comes from many development wells were drilled had gain production above target. Peak non associated gas production at 8.4 MMSCFD in 1988 from Baturaja formation.

2. Basic Theory

Analysis were performed on data acquired during dedicated operations called well test. In exploration well, well test analysis is used to measure the initial pressure, estimate a minimum reservoir volume, evaluate the well permeability, skin effect, and identify heterogeneities and boundaries. On producing wells, its used aims at verifying permeability and skin effect, identifying fluid behavior, estimating the average reservoir pressure, confirming heterogeneities and boundaries, and assessing hydraulic connectivity especially for evaluation after an stimulation or fracturing job had done.

To identify an interpretation model that relates the measured pressure change to the induced rate change and is consistent with other information about the well and reservoir. This is an inverse problem without a unique solution. Petroleum professionals are confronted with the inverse problem whenever they interpret data and model processes (for instance, in geophysical interpretation, in geological interpretation, in log interpretation, and in the reservoir modeling aspect of reservoir simulation). The problem of nonuniqueness is well recognized in the oil industry and accounts for the increasing use of stochastic modeling techniques, which aim at providing alternative equiprobable representations of the reservoir to capture the uncertainty associated with predictions. Nonuniqueness decreases as the amount of information increases.

As illustrated in **Fig. 1**, there are two possible signals we can use to identify an interpretation model. One is the difference $\Delta p=[p(\Delta t)-p(\Delta t=0)]$

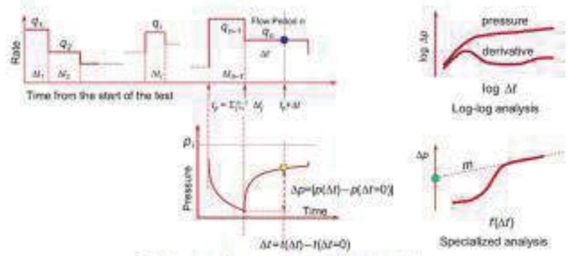

Fig. 1—Log-log and specialized analysis.

between the pressure $p(\Delta t)$ at an elapsed time Δt in a flow period and the pressure $p(\Delta t=0)$ at the start of the flow period (a flow period is a period during which the rate is constant). This signal and its derivative with respect to the superposition time are plotted on a log-log graph.

In such a graph, various flow regimes (e.g., linear, bilinear, spherical, radial) exhibit distinctive shapes and occur at different times, and this is used to identify them (log-log pressure and derivative analysis). The existence of the flow regimes can be verified on flow-regime-specialized graphs by plotting $\Delta p=[p(\Delta t)-p(\Delta t=0)]$ vs. $f(\Delta t)$ on a Cartesian graph (specialized analysis), where f is a flow-regime-specific function. $f(\Delta t)$ is equal to Δt for wellbore storage and pseudosteady-state flow, for linear flow, for spherical flow, $\log(\Delta t)$ for radial flow, etc.

The other signal is $[p - p(\Delta t)]$, where p is the initial pressure **(Fig. 2).** Because p is usually not known, the signal is actually $p(\Delta t)$, to be plotted against a flow-regime-specific superposition time, on a Cartesian plot (Horner analysis). $f(\Delta t)$ is the same as for specialized analyses.

In both specialized and Horner analyses, a straight line is obtained where the flow regime dominates and the straight-line slope and intercept provide

the well and reservoir parameters that control this flow regime.

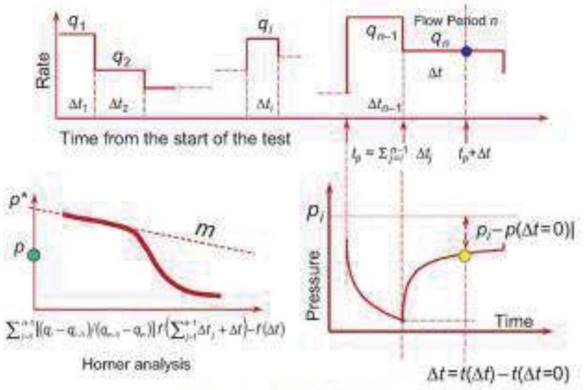

Fig. 2—Horner analysis.

Acidizing and Fracturing are the basic choices when wants to improved the productivity of a well especially when a well produce from tight layer. Fracturig requires a mechanical stress induced by the resistence to the flow and will be typically performed in low permeability formations. In these case, is the producing potential oil from tight layers. Once fracture is initiated, the bottom hole pressure kept while propant such as sand is included in the fracturing fluid. As the fracture screen out, the induced fracture faces remain open.

At early time behaviour only the part of the reservoir in front of the fracture will significantly contribute to well production, orthogonal to the fracture plane. This is what we call the linier flow and this is characteristic feature.

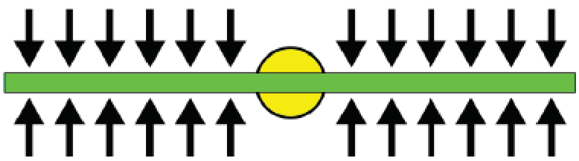

Fig.3 Early time linier Flow

The most common example of a well model transformation is when a well subject to fracture stimulation. Typically the well is damaged and no fracture is intersecting the well during the first status or time period of a well test. Then the well is subject to the fract job and the well model is changed to fracture model. It is possible to model this using a time dependent well model. The history is devided into time periods with certain status, and each status can have the following definitions:

- Status with constant wellbore storage and skin
- Status with changing wellbore storage
- Rate dependent skin for each status
- Status with infinite, uniform flux or infinite conductivity fracture.
- Each status can have a different geometry limited entry.
- Each status can have a different horizontal well geometry.

The figure below illustrated the loglog match of the well behaviour before and after a fracture stimulation job. The model matches the whole history of the test sequences including the fracture treatment.

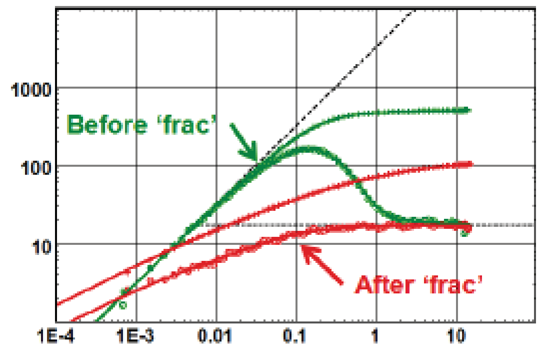

Fig.4 Changing Well Loglog Match

There two types of fracture models: the high or infinite conductivity and finite conductivity, there are two main high conductivity fracture models: the Uniform Flux model assumes a uniform production along the fracture. the infinite conductivity model assumes no pressure drop along the fracture.

In early time region of high conductivity fracture is characterized on a log log plot by a half-unit slope on both the pressure and derivative curves. The level of the derivatives is half of the pressure. At later time there is a transition away from this linier flow towards infinite acting radial flow, where derivative stabilizes **fig.5**

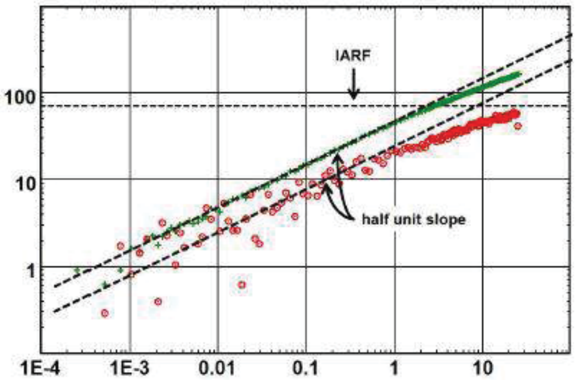

Fig. 5 Infinite Conductivity Fracture Behavior

The position of these two half slope straight lines will estabilish a link between time match and the pressure match, providing a unique result for kX_f^2. Fixing the stabilization level of the derivative will determine the value of k, and the half fracture length will be calculated from kX_f^2. If there is no clear stabilization level the problem will become underspecified.

Fracture geometrical skin can be analized when we run a standard straight line analysis on logarithmic scale (MDH, Horner, Superposition) and calculated a value of the skin factor, this is call the total skin. This calculation may take place at any time after extraction of the build up, and is independent of the model chosen. Total sikin is given by the equation.

$$S_T = \frac{kh}{141.2 q_{sf} \mu} \Delta p_{Skin}$$

Where ΔpSkin is the pressure difference between recorded data and the response of a standard, undamaged, fully penetrating vertical well.

3. Methodology

By understand the various characteristic layers in Ogan Field, well testing was used to predict the characteristic of each reservoir and delivered analysis result to choose well intervention method to increase production.

BHP survey tools is a device to recorded downhole pressure and temperature with decided program. There are two types of BHP survey tools, conventional record and real time record.

The advantages real time record tools we can monitor pressure and temperature behavior live at surface and load the data while it still recorded, so we can decided to finish recording when we have enough data to interpretated.

On the other hand, conventional recorded is easy to prepare, however this tool has disadvantage we cannot monitoring survey data, and sometimes we have not enough data after it downloaded at surface, then measurement program should be restart with extended shut in period.

In this case, we use conventional pressure record to measure bottom hole pressure and temperature. Hera are job sequences to initiated well testing analysis.

First, we design well test model along with input reservoir characteristic from log interpretation and decided shut in well time period to estimated wellbore storage and radius of investigation.

Second, we program shut in pressure survey followed by measuring static and flowing gradient pressure to estimated static and dynamic fluid level.

Third, set up slick line unit, rig up lubricator, run in hole pressure survey tool while measuring flowing gradient pressure until reach measure depth, flowing pressure measured for one hour. Then, shut in well to measure build up pressure as we design at first step. After shut in measurement finish then pull out pressure survey tool to surface while measuring static gradient pressure. Last, downloaded recorded data and delivered it for analysis and interpretation.

4. Case Study

In this case, well testing is used to analyze reservoir changes after fracturing and find the causes of fracturing does not affect to increase production. There are two wells has typical problem after fracturing the production rate below target. In addition, we put one well which has success story for comparation.

The first well OGN XX1 was produced from two layers a0,a01 where as known as tight layer describe from low production test after those two layers was perforated. Well test performed to obtain reservoir characteristic before well intervention, the results are positive skin, high pressure drop, low permeability and low productivity index **Fig 6**, these results of well test are used to initiated fracturing job in this well.

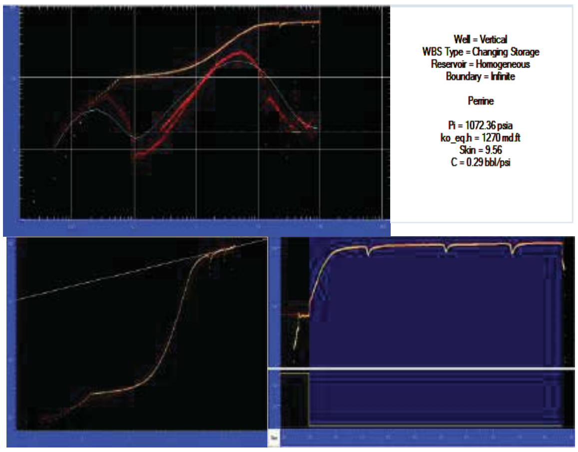

Fig.6 Well Test Analysis Before Fracturing

After fracturing job the initial production has increase, however rate of production was decreased the day after. OGN – XX1 decide to measure bottom hole pressure survey by shut in test for 72 hours.

Analysis from well test show that OGN – XX1 in early time region has a fracture model where is characterized on a log log plot by a half-unit slope on both the pressure and derivative curves **Fig.7**. We choose Uniform flux as fracture model which assumes a uniform production along fracture. from interpretation shows that half length X_f was below as designed.

Although fract model was build in OGN – XX1, skin remain postive but lower than before which is indicates the wellbore has minor damage.

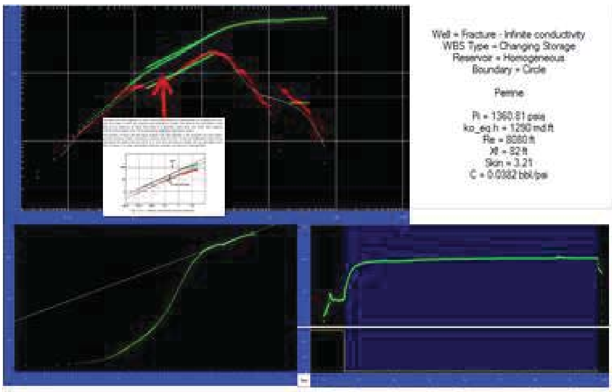

Fig.7 Derivative Curves Shows Fracture Model.

Similiar case happened at OGN XX2 where was produced from tight layer, the well was not produce after perforated, then fracturing initiated without welltest analysis. After fracturing the well produce with low prodution rate. The suspect for this kind problem as same as OGN XX1 before. Therefore pressure bottom hole survey performed with shut in pressure program in 72 hours.

Analysis from well test show that OGN – XX2 has same problem like OGN XX1, in early time region has a fracture model where is characterized on a log log plot by a half-unit slope on both the pressure and derivative curves **Fig.8**. Infinite conductivity had choose as fracture model for interpretation, it shows that half length X_f was below as designed and skin remain postive but lower than before which is indicates the wellbore has minor damage.

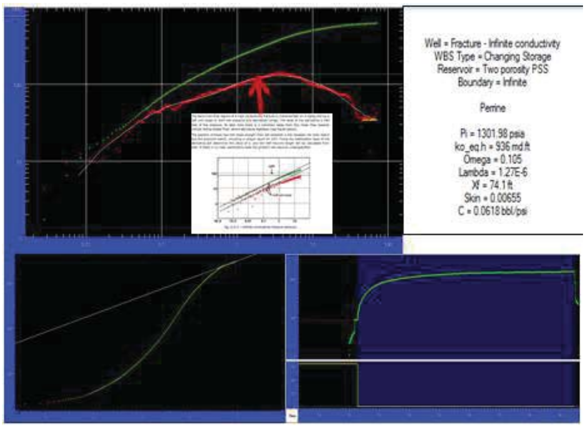

Fig.8 Derivative Curves Shows Fracture Model.

For comparation, the success story of fracturing was in OGN XX3 where it has typical reservoir characteristic, producing from tight layer we initiate to programmed for fracturing stimulation.

To evaluate fract job, well test was porgrammed with shut in period for 48 hours. From analysis, log-log plot or pressure derivative show that well model has fracture with high conductivity as figure 9.

Interpretation result show half length was around 282 ft, it was almost similiar with design where expected half length was 171 ft and skin has change into negative value which mean there was no damaged in wellbore area.

Result also show wellbore has negative skin and increase permeability near wellbore around 728 md. By this result fracturing job in OGN XX3 had success to changes reservoir characteristic.

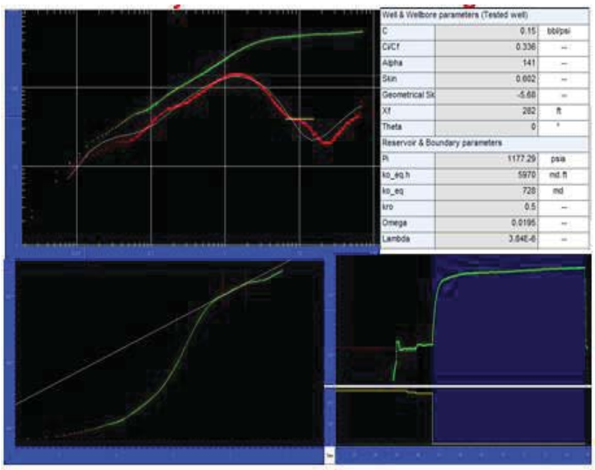

Fig.9 Derivative Curves Shows Fracture Model In OGN XX3.

The success of fraturing also validate with production rate , flowing pressure and absolute open flow potenstial has increase than before.

5. Result and Discussion

The use of well test is important to understand reservoir characteristic and post job evaluation after fracturing or stimulation done in a well.

The results of well test we know the causes rate production below target, from interpretation on log-log plot we identify reservoir has fracture model define from half slope between pressure and derivative, however the half length of fracture not optimum.

Well test interpretation result on OGN XX1 show half length was around 82 ft and from design expected half length was 250 ft and skin effect remain positive. by this result fracturing job need further evaluation.

Post job evaluation indicates fracturing gel failed to break therefore the half length fracture below as designed. The next step to resolve this problem is inject gel breaker and perform acid stimulation.

Similiar case with previous well, OGN XX2 from well test interpretation result show half length was around 37.6 ft and from design expected half length was 120 ft and has postive skin 0.1, altough the skin value has decreased almost zero, it still indicates minor damage was remain near wellbore. By this result as we recommend that before, fracturing job need further evaluation.

Post job evaluation indicates fracturing gel failed to break therefore the half length fracture below as designed. The next step to resolve this problem is inject gel breaker and perform acid stimulation.

After Acid mix with gel breaker stimulation, those two wells had gain production rate almost three times than before. It was a success story how well test is usefull to analyze reservoir behavior after well inervention.

From analysis OGN XX3 as we describes in previous section, shows fracturing has success to changes skin effect into negative skin and increase permeability near wellbore its indicate build up pressure quickly increase and stabilize after shut in pressure initiate. It was also indicate reservoir influx has run smoothly into wellbore so flowing pressure has raised as well.

6. Conclusion

From analysis study described above fracturing in Ogan Field actually is suitable to increase production where several layers were tight formation. From case above well test is important to evaluate and validate post job fracturing.

As we describe at previous section, from well test analysis we can conclude fracturing job in several wells has improved reservoir characteristic by changing wellbore model became fracture. However,there was slightly error in operational that made actual result as not we expected.

Well test results identify moderate skin value after fracturing shows a minor damage near wellbore had deliver us to evaluate post job fracturing to identify

7. Recommendation

Analysis from well test can also compare reservoir changes after well intervention and give recommendation for further development on a well. At this case,well testing use to identify the causes production rate below target after well had been fraturing and give recommendation next step to gain target as we desired.

Based on this case, well test result has identify the causes of production has yet increase and gave recommendation for further evaluation.

After fracturing job we should compare the post job results between well test analysis and post job fracturing design summary for evaluation to create a perfect design for the next fracturing job.

Based on this case, operetionally the use of fresh water should pay more attention and requires further lab test analysis when mixing with gel fluid in order to get a perfect timing for gel to break.

Well test data can use to create IPR to estimate well production capacity then give recomendation to optimize the potential production by changing a lifting method.

Re – fracturing might be option for feature plan in OGN XX1 and OGN XX2 consider the half fracture length below design.

8. Acknowledgement

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List of Figures

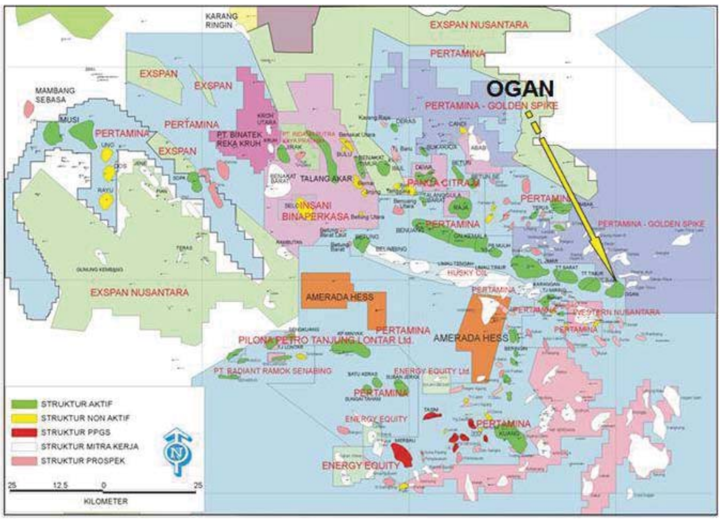

Figure 1. Map Location of OGN Structure

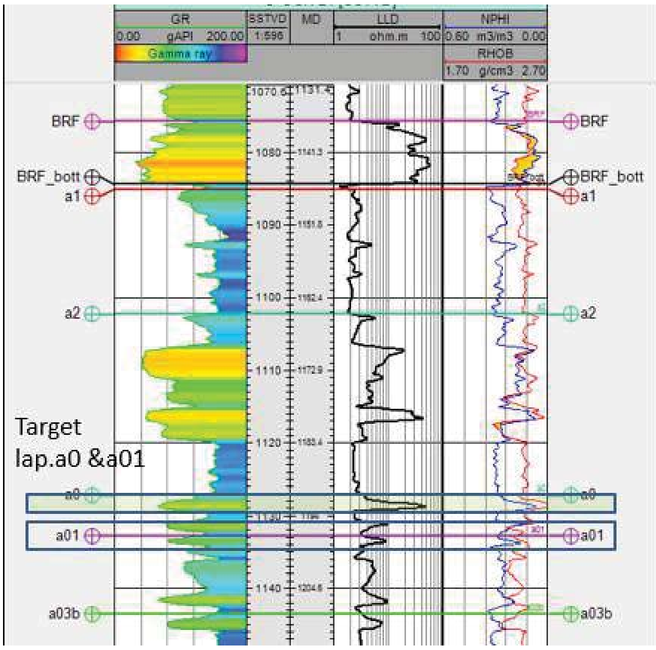

Figure 2. Type Log OGN XX1

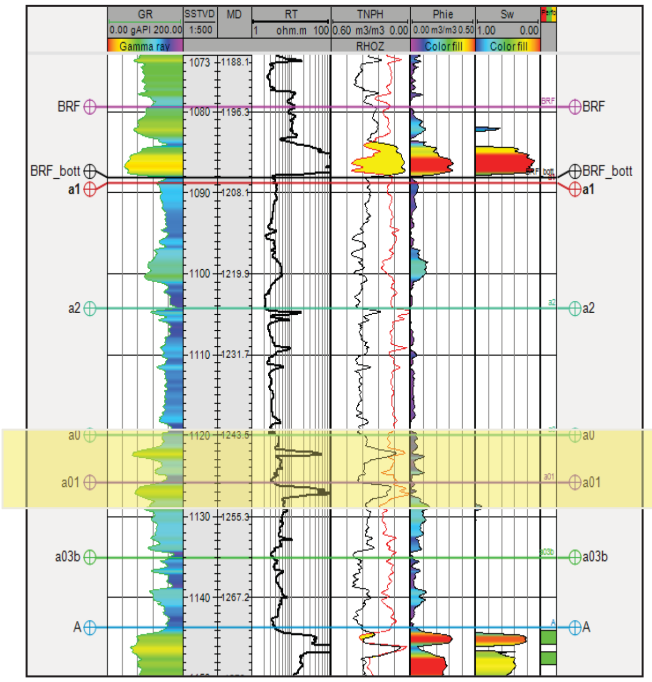

Figure 3. Type Log OGN XX2

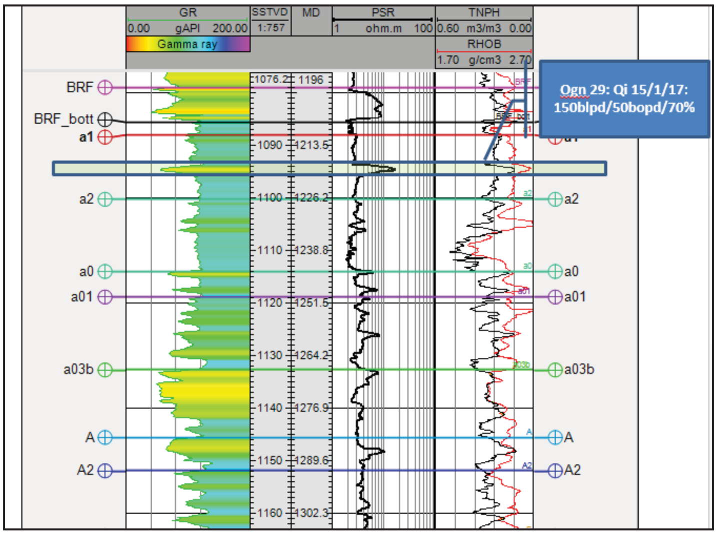

Figure 4. Type Log OGN XX3

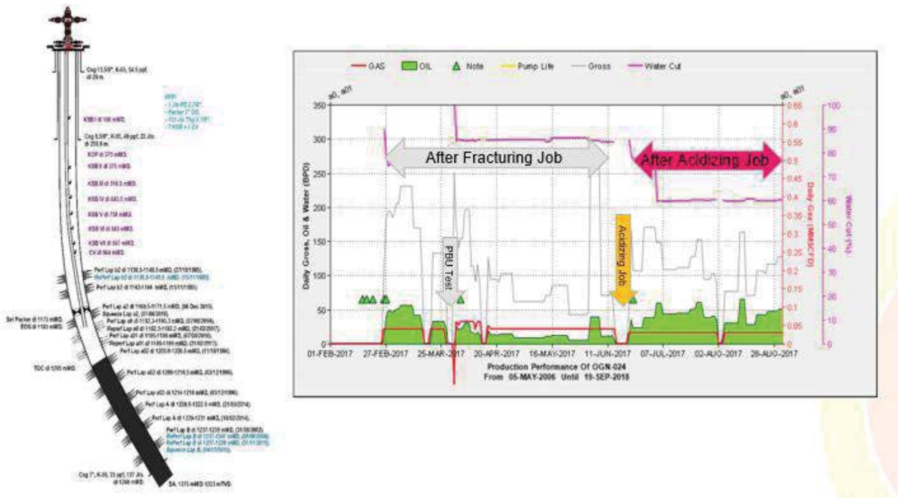

Figure 5. Well Schematic And Production Performance OGN XX1

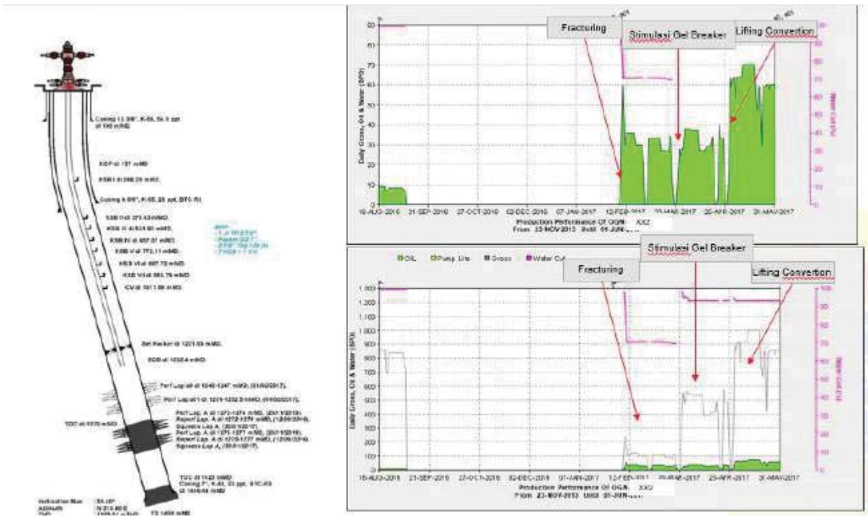

Figure 6. Well Schematic And Production Performance OGN XX2

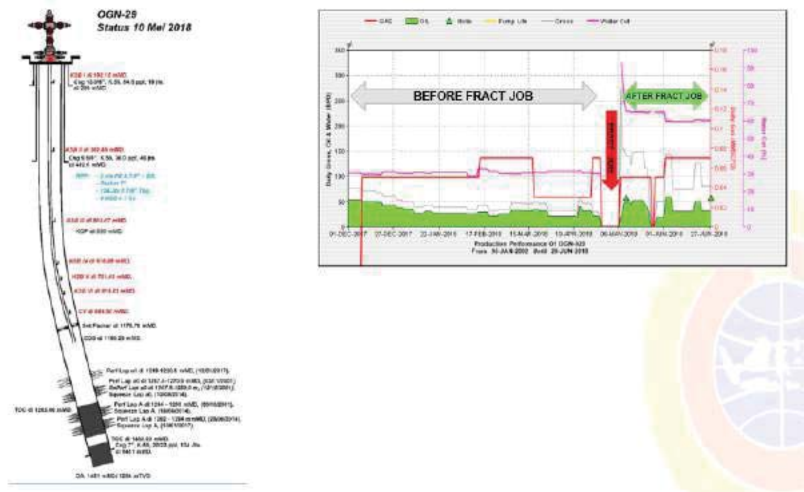

Figure 7. Well Schematic And Production Performance OGN XX3

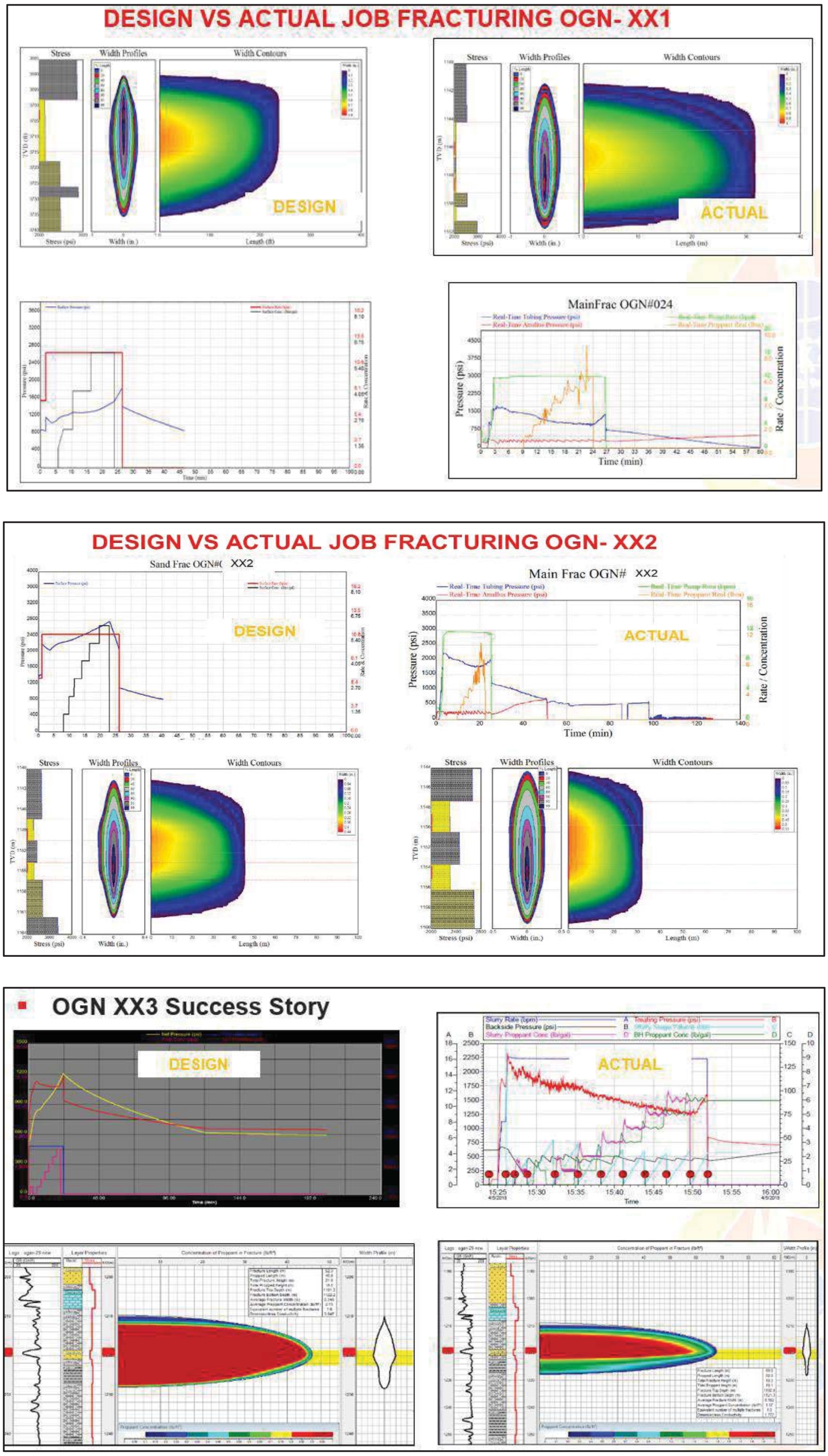

Figure 7. Fracturing Simulation Design Plan vs Actual Ogan Well