Diagnosing Complex Flow Characteristics of Mishrif Formation in Stimulated Well Using Production Logging Tool

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Abstract

Production logging is used to diagnose well production problems by evaluating the flow profile, entries of unwanted fluids and downhole flow regimes. Evaluating wells production performance can be easily induce from production logs through interpretation of production log data to provide velocity profile and contribution of each zone on total production. Production logging results supply information for reservoir modeling, provide data to optimize the productivity of existing wells and plan drilling and completion strategies for future wells. Production logging was carried out in a production oil well from Mishrif formation of West Qurna field, with the objective to determine the flow profile and fluid contributions from the perforations after the stimulation job. The measurements were made under shut-in and three choke sizes (60/64”, 46/64” and 32/64”) flowing conditions. Overall, the data quality is acceptable to generate a good analysis. From the flowing surveys, it was observed that just the intervals 2250-2285 m and 2335-2375 m are contributing to the total well production while the well was flowing through the chokes 60/64” and 46/64”. However, most production is coming from the interval 2250-2285 m for each choke. The flow profile changed with the 32/64”, the interval 2250-2285 remained producing but the interval 2335-2375 m started receiving fluid from the upper interval. This cross flow increased after the well was shut in. The temperature log shows a normal behavior while the well is flowing through the 60/64” and 46/64” chokes, but changes as result of the cross flow with the 32/64” choke and with the well shut in. From the capacitance readings and pseudo fluid density (density from differential pressure) only oil is being produced, and there is a static water column at the sump.

Keywords: Complex Flow Characteristics, Production Logging Tool

تشخيص خصائص الجريان المعقد بتكوين مشرف في احد الابار المنعشه باستخدام مجس فحص الانتاج

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الخلاصة:

تستخدم مجسات فحص الانتاجية لتقييم مقاطع الجريان، وكذلك تحديد المناطق التي يتسرب بها الموائع وطبيعة حركة الموائع. تقييم الابار المنتجة باستخدام مجسات الانتاجية تتم بسهولة من خلال تفسير البيانات

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للتعرف على المناطق المساهمة والمنتجة وسرعة الجريان عند كل عمق. توفر نتائج المجسات الانتاجية معلومات هامة للنمذجة المكمنية وللخطط المستقبلية لعملية الحفر. في هذه البحث تم الاستعانة بمعلومات مجسات الانتاجية في احد الابار المنعشة في تكوين مشرف بحقل غرب القرنة للتعرف على مقاطع الانتاج للطبقات وطبيعة الانتاجية من ثقوب بطانة جدار البئر. تمت القياسات تحت ظروف اغلاق البئر باستخدام ثلاثة احجام مختلفة من الخوانق (”60/64“, 46/64” 32/64) تحت ظروف انتاجية. من خلال مسح الجريان لوحظ ان المقطعين 2250–2285 و 2335–2375 متر تساهم بشكل كبير من الانتاج الكلي في حالة جريان البئر باستخدام الخوانق ”60/64 و ”46/64 .

Introduction

Production logging is used to diagnose well production problems by evaluating the flow profile, entries of unwanted fluids and downhole flow regimes. Evaluating wells production performance can be easily induce from production logs through interpretation of production log data to provide velocity profile and contribution of each zone on total production. Production logging results supply information for reservoir modeling, provide data to optimize the productivity of existing wells and plan drilling and completion strategies for future wells [1,2]. B.L Knight et al. [3] developed models for flow loop for two flowmeters to predict performance, by using wireline contractor production software. Various combinations of production log provide methods of evaluating cased hole well performance. Production logs are used to detect fluid channeling, coning and cross flow in addition to establishing flow rates and flow profiles in producing and injection wells [4]. While the production logs surveys and increased stimulation add to the cost of initial completion, the added productivity has been equivalent to drilling another well in one instance and drilling half well in another, production logging surveys should certainly be continued as means of improving engineered completions of gas and oil wells [5]. T. R. Fountain [6] presented two example of use the production log to show the effect of a large volume, high rate acid stimulation on the reservoir and presence of formation water in the bottom of the producing interval.

The Continuous Flowmeter Interpretation:

The Flowmeters can be most accurately calibrated by the in-situ technique. This consists of recording the tool's response in revolutions per second (rps) while moving at several known absolute velocities, both up and down, within the moving column of fluid figure-1. From these recordings, exact relationships can be established between the rps of the tool and fluid velocity in ft/min. Thus the logs contain their own calibration data as well as the data needed for analysis. To corroborate and support the calibration, readings are also normally taken at several points in the well with the tool stopped. Figure-1 show the bottom of a dump-flood well, where water is being produced from three sets of perforations [1]. The fluid is monophasic and, hence, the Fullbore Spinner is usable over all ranges of flow. Note that Flowmeter readings are taken between perforated intervals, at stations marked A, B, C, and D. (Readings taken within perforated sections may be affected by local turbulence. Note that on the upper part of the log the spinner speed is higher with the tool run downward than upward. Also observe, down deeper that with the tool run upward (in the same direction as the water flow there is a section of zero spinner speed and, below that, a reversal of spinner direction. As the tool travels upward from the bottom at constant speed, it is at first moving faster, then at the same speed, and finally slower than the water. These several must be inferred because the log does not differentiate between upward and downward flow. In figure-1 the reversals are marked.

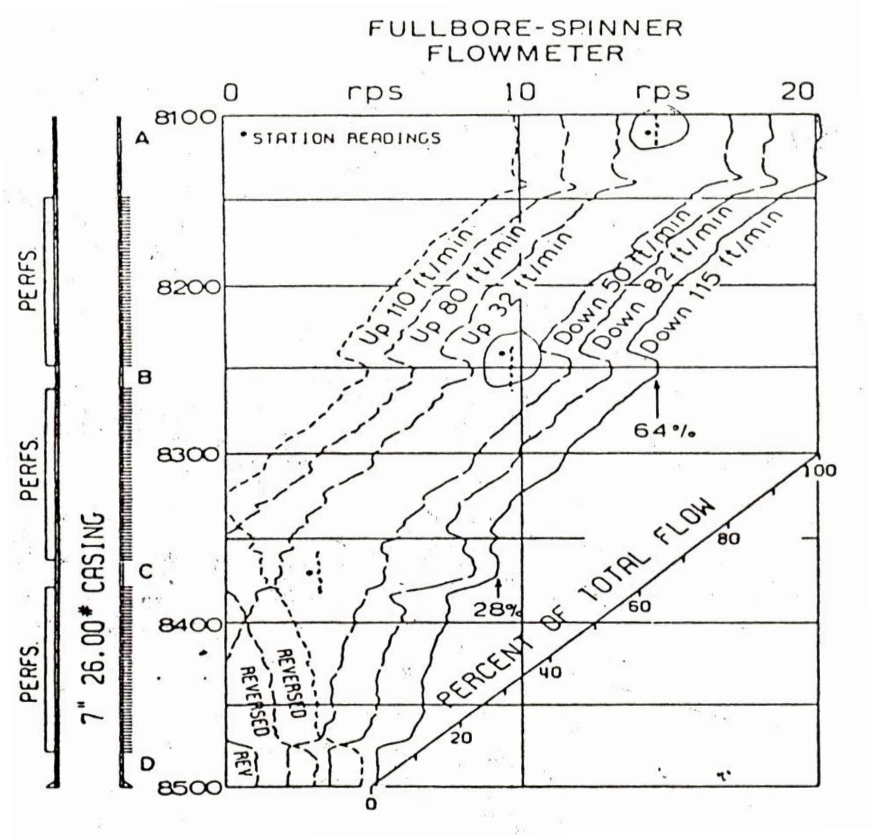


Figure 1- Fullbore-spinner Flowmeter in a dump-flood well [1].

Results and Discussion:

A Production logging was carried out for the well WQ-89, an oil producer from Mishrif Formation of West Qurna field, with the objective to determine the flow profile and fluid contributions from the perforations after the stimulation job performed. The measurements were made under shut-in and three choke sizes (60/64”, 46/64” and 32/64”) flowing conditions. From the flowing surveys, it was observed that just the intervals 2250-2285 m and 2335-2375 m are contributing to the total well production while the well was flowing through the chokes 60/64” and 46/64”.

However, most production is coming from the interval 2250-2285 m for each choke. Overall, the data quality is acceptable to generate a good analysis. Figures-2, 3, 4, 5, 6 & 7 represent the calibration and log processing data; it was observed that just the intervals 2250-2285 m and 2335-2375 m are contributing to the total well production while the well was flowing through the chokes 60/64” and 46/64”. However, most production is coming from the interval 2250-2285 m for each choke. All pressure values are referred to 2250 m.

The well WQ-89 was producing 5000 stb/d. A new zone of known better quality reservoir (mA) was added on top and then the two zones were stimulated together. The resulting flow rate was 3838 stb/d . It follows an explanation of this well behavior.

The Figure-8 shows the IPR plot for well WQ-89. The blue solid line is the least square fit of the flow rates and pressures obtained during the PLT survey for the new added perforated interval 2250-2285m showing a PI(Productivity Index)=19.9 stb/d/psi and a layer pressure of 2952.5 psia. The same was done for the lower layer (shown in solid red) 2335-2375m showing a PI=18.0 stb/d/psi and a layer pressure of 2832 psi.

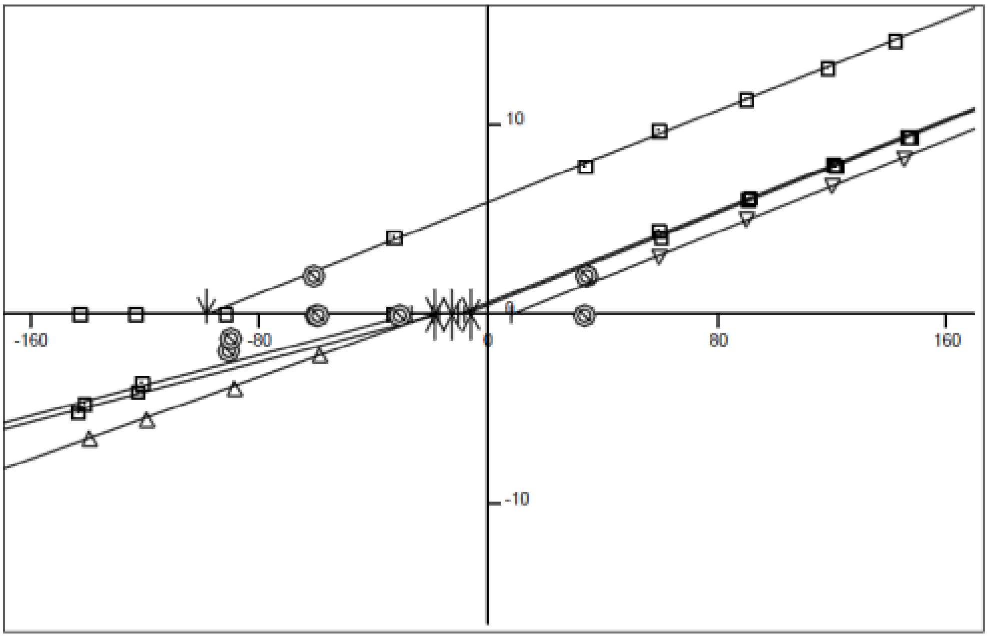
Notice that there was a crossflow of 1021 stb/d from the upper layer (high pressure) to the lower layer (low pressure) during shut in conditions with 2900 psia at 2250 m. Notice also that with full choke of 60/64”, the bottom hole flowing pressure was 2795 psia at 2250m, the WHP was 472 psia and the contributions from the upper zone was 3048 stb/d while the lower interval was producing 790 stb/d.

Before perforating and stimulating the well, the test indicated that the well was producing about 5000 stb/d with WHP=390 psi. As the WHP at full choke is 472 psia we believe this pressure can be lowered "at least" to 390 psi by increasing the choke size, without equalizing the system pressure.

The green lines indicate that with WHP=390 psi, the bottom hole flowing pressure would be 2710 psi and the upper zone will contribute 4700 stb/d while the lower zone would contribute with 2100 stb/d, making a total of at least 6800 stb/d.

It also expected that the stimulating fluid was injected mainly in the lower pressure lower perforated interval and the increased flow rate would help to clean out this zone improving its Productivity Index. Any value of WHP below 390 psi, that allow the well to produce above the system pressure, will improve the above predicted flow rate results.

Table-1, shows the PLT Calculated Rates at Reservoir Conditions. Where the values are directly taken from the production logging interpretation at bottom hole; they do not depend on the volumetric factors. They are function of the Casing ID and the calculated flow velocity from the flowmeter. The summary of the zonal contributions at surface conditions for the flowing and shut in conditions is given in table-2.



rps versus ft/min

	Calib. Zone m	Slope (+)	Slope (-)	Int (+) ft/min	Int (-) ft/min	Int. Diff. ft/min	Thr. (+) ft/min	Thr. (-) ft/min
⊡	2241.3-2246.5	0.060	0.040	-98.79	N/A	0.00	0.00	0.00
○	2289.4-2302.2	0.060	0.040	-8.86	-17.58	8.72	4.36	-4.36
+	2330.5-2333.6	0.060	0.040	-10.65	-27.24	16.58	8.25	-8.25
×	2376.5-2380.8	0.060	0.055	7.62	-20.14	27.75	13.88	-13.88

Figure 2- Calibration Plot for the Choke 60/64"

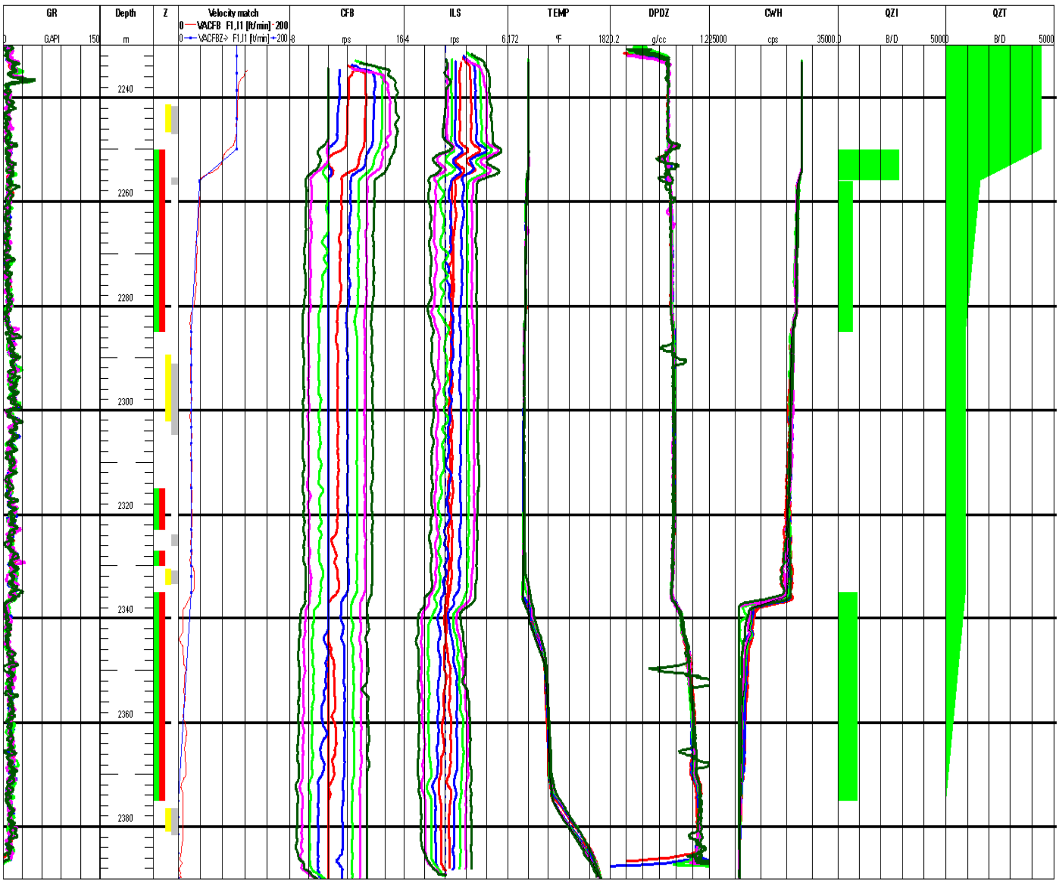
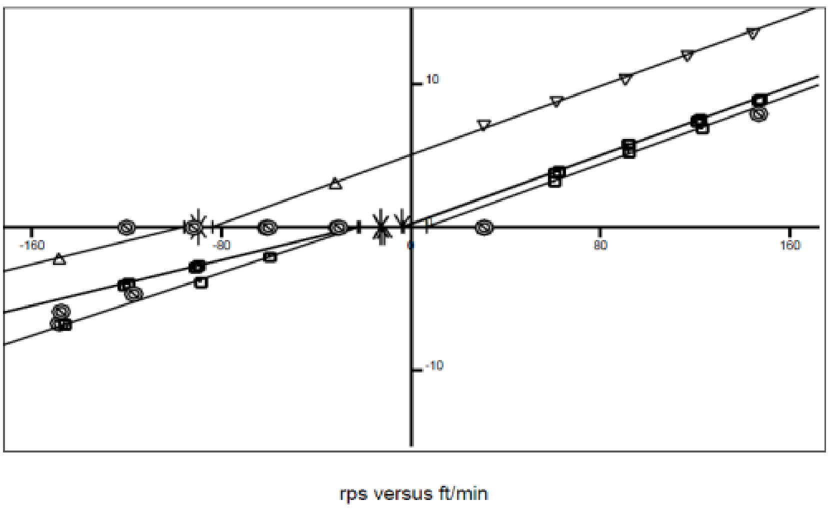


Figure 3- Production Log-Processing Results (Flowing Choke 60/64")



	Calib. Zone m	Slope (+)	Slope (-)	Int (+) ft/min	Int (-) ft/min	Int. Diff. ft/min	Thr. (+) ft/min	Thr. (-) ft/min
□	2241.3-2246.5	0.060	0.040	-83.39	-95.88	12.50	6.25	-6.25
○	2289.4-2302.2	0.060	0.040	-3.44	-21.49	18.05	9.03	-9.03
+	2330.5-2333.6	0.060	0.040	-2.92	-22.53	19.62	9.45	-9.45
×	2376.5-2380.8	0.060	0.055	6.67	-21.47	28.14	10.25	-10.25

Figure 4- Calibration Plot for the Choke 46/64"

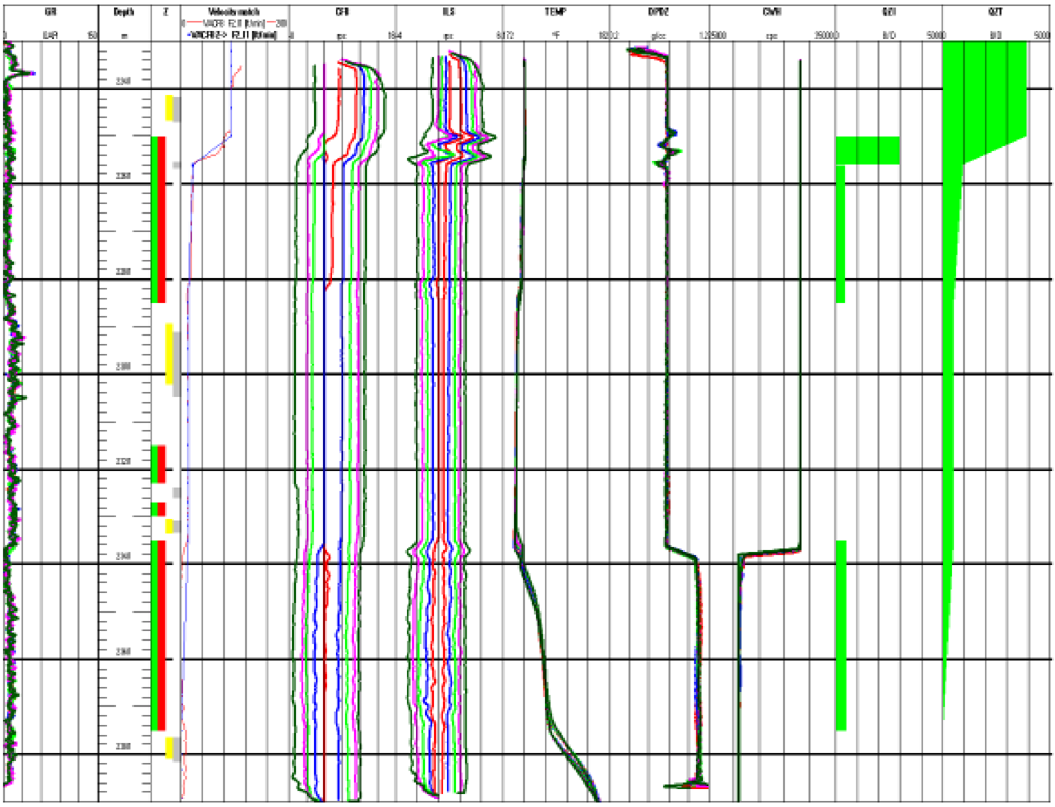
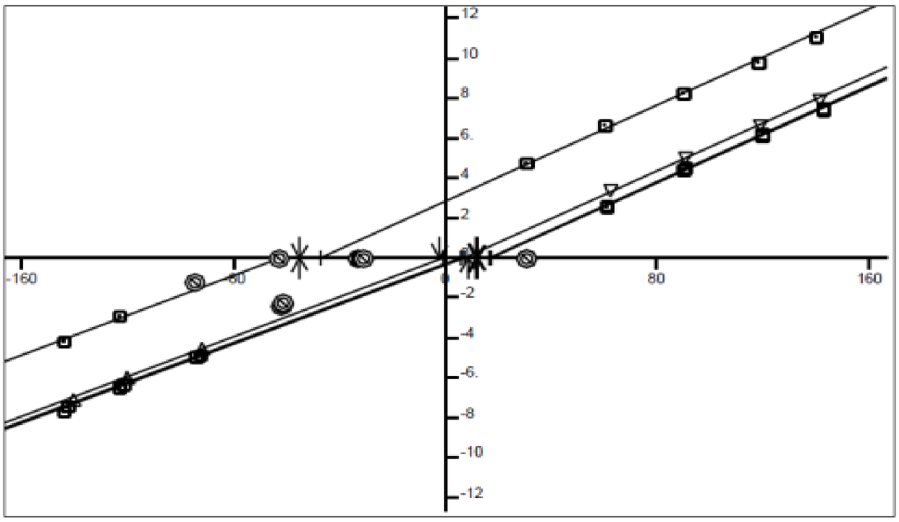


Figure 5- Production Log-Processing Results (Flowing Choke 46/64")



rps versus ft/min

	Calib. Zone m	Slope (+)	Slope (-)	Int (+) ft/min	Int (-) ft/min	Int. Diff. ft/min	Thr. (+) ft/min	Thr. (-) ft/min
□	2241.3-2246.5	0.060	0.050	-47.50	-62.67	15.17	7.59	-7.59
○	2289.4-2302.2	0.060	0.050	16.82	7.53	9.29	4.65	-4.64
+	2330.5-2333.6	0.060	0.050	17.59	5.90	11.68	5.84	-5.84
×	2376.5-2380.8	0.060	0.050	7.32	-0.86	8.17	9.39	-9.39

Figure 6- Calibration Plot for the Choke 32/64"

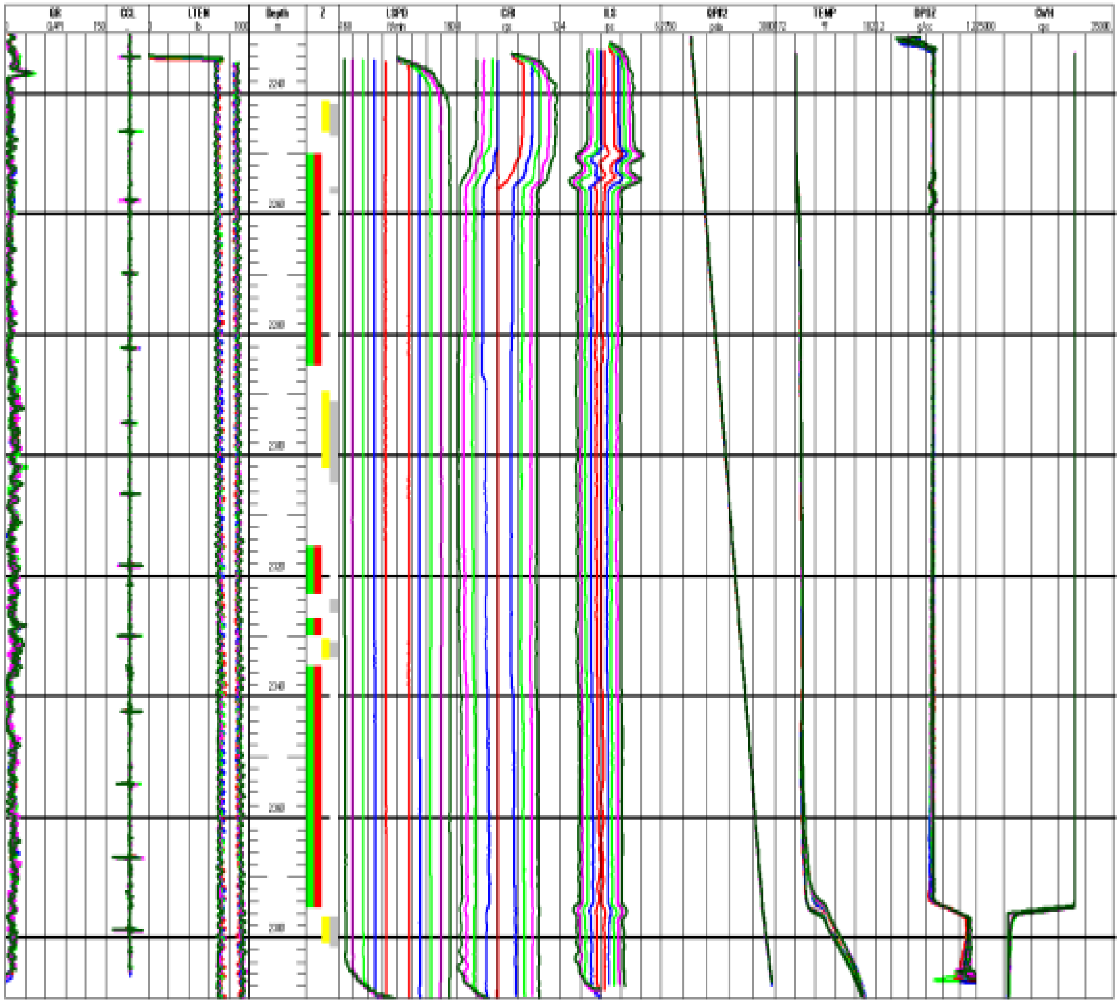
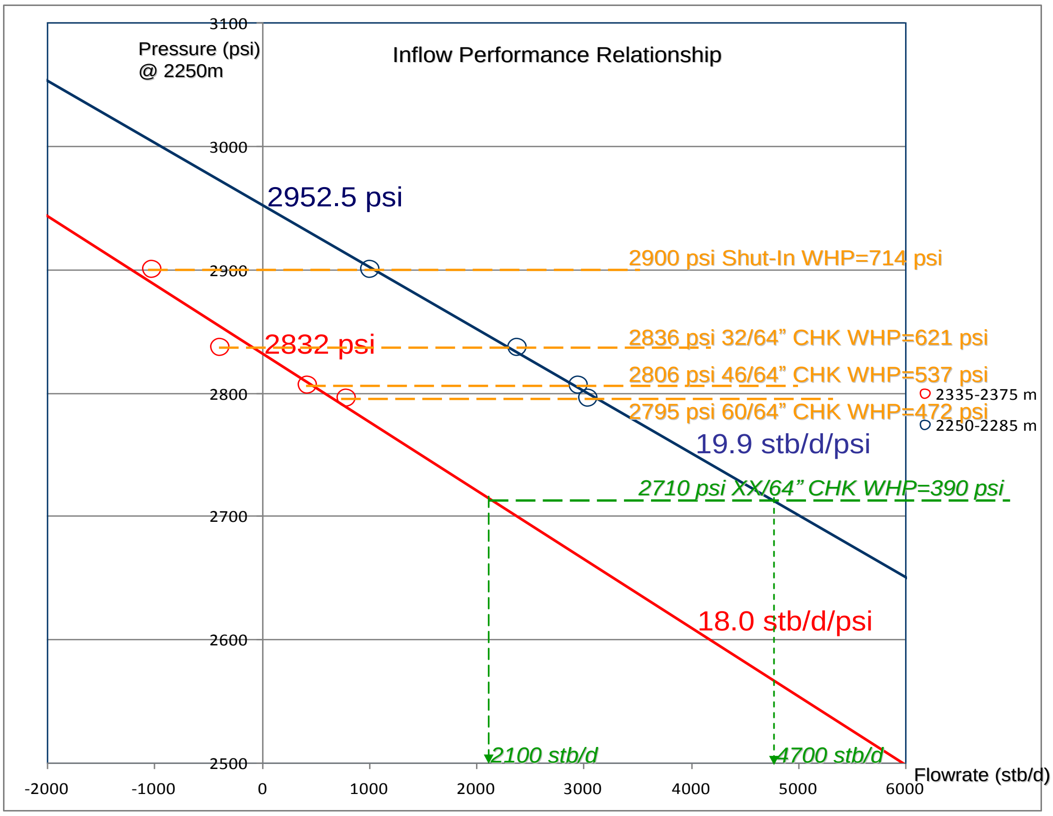


Figure 7- Production Log-Processing Results (Flowing Choke 32/64")

Recommendation

It would be very helpful to perform a complete well cleaning after the stimulation jobs, to prevent the presence of debris bellow the perforated intervals.



Interval	A = 2250-2285 m		B = 2315-2323 m		C = 2327-2330 m		D = 2335-2375 m	
Choke	Qo (stb/d)	Pressure (psi)	Qo (stb/d	Pressure (psi)	Qo (stb/d	Pressure (psi)	Qo (stb/d	Pressure (psi)
32/64"	2383	2836	0	2836	0	2836	-387	2836
46/64"	2956	2806	0	2806	0	2806	439	2806
60/64"	3049	2795	0	2795	0	2795	791	2795
Shut-in	1021	2900	0	2900	0	2900	-1021	2900
Productivity Index (stb/d/psi)	19.9		0		0		18.0	

Figure 8- Inflow Performance Relationship

Table 1- PLT Calculated Rates at Reservoir Conditions.

	Choke 60/64"			Choke 46/64"			Choke 32/64"			Shut In		
Perforated Intervals (m)	Water (RB/D)	Oil (RB/D)	Gas (MSCF/D)	Water (RB/D)	Oil (RB/D)	Gas (MSCF/D)	Water (RB/D)	Oil (RB/D)	Gas (MSCF/D)	Water (RB/D)	Oil (RB/D)	Gas (MSCF/D)
2250-2256	0	2834	0	0	2978	0	0	2460	0	0	1106	0
2256-2285	0	678	0	0	428	0	0	283	0	0	68	0
2315-2323	0	0	0	0	0	0	0	0	0	0	0	0
2327-2330	0	0	0	0	0	0	0	0	0	0	0	0
2335-2375	0	910	0	0	505	0	0	-446	0	0	-1174	0
Total	0	4422	0	0	3910	0	0	2298	0	0	0	0

Table 2- PLT Calculated Rates at Surface Conditions.

	Choke 60/64"			Choke 46/64"			Choke 32/64"			Shut In		
Perforated Intervals (m)	Water (STB/D)	Oil (STB/D)	Gas (MSCF/D)	Water (STB/D)	Oil (STB/D)	Gas (MSCF/D)	Water (STB/D)	Oil (STB/D)	Gas (MSCF/D)	Water (STB/D)	Oil (STB/D)	Gas (MSCF/D)
2250-2256	0	2461	639.8	0	2585	672.2	0	2137	555.5	0	961	249.9
2256-2285	0	588	153.0	0	371	96.6	0	246	64.0	0	59	15.3
2315-2323	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
2327-2330	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
2335-2375	0	791	205.6	0	439	114.1	0	-387	-100.7	0	-1020	-265.2
Total	0	3840	998.3	0	3396	882.9	0	1995	518.8	0	0	0

Conclusions

Most of the oil production is coming from the perforated interval 2250-2285 m. The estimated productivity index for this zone is 19 stb/d/psi. The intervals 2315-2323 m and 2327-2330 m are not producing any fluid. There is an over 1000 bpd cross flow under shut in conditions. A static water column is at the sump.

The pressure build up test performed in the well could be affected by the cross flow, and the results must be considered only as a reference (K=684 md, S=-3.7, P=3045 psi @ 2385 m).

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