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An Evaluation of Well Deployment Aspects Affecting Well Flow Performance on Horizontal Production Log Results

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Abstract

Production logging uses measurements to understand the velocity & fluid types comingling as open reservoir intervals deliver products which begin to flow up hole. In a horizontal flowing well environment, the logging tools of choice can be individual discreet measurements situated across the cross sectional flow area to measure and define the fluid type & velocity. Flow measurements are much more difficult to measure as most horizontal flowing environments are not stable. Deployment of this tool type can be conveyed using a coiled tubing setup or a well tractor conveyed tethered to a wireline. These deployment methods can have an effect on the flow regime during the logging survey.

When oil company operations engineering teams require production log data across a flowing lateral, one aspect seldom addressed is how the deployment intervention can affect the well flow performance when deploying the production logging measurements.

Often times the perturbation causing the well performance is based on the deployment intervention selection. This in return causes the well to underperform at the point in time a production logging survey is needed; leaving the logging technology with an unstable environment to deliver a confident result.

What tends to occurs within the engineering teams is the perception that there is an inability of present day technology to accurately measure the well performance, meanwhile the deployment aspect chosen & the procedures to convey a production log actually can be a main culprit in changing the well flow dynamics & stability.

Via deployment experience & a thorough understanding of well flow combined with production log analytical skill sets. This technical paper will discuss in a case history a production log run in a horizontal well, the deployment aspects & well flow challenges using wireline tractor & coiled tubing interventions, and how the end result was able to assist the customer.

Deployment Case History

The case history chosen was a horizontal well recently completed flowing back mostly water & very little oil rate. The casing pipe size is 5 ½”17 lb. Casing with an ID of 4.892 inches and the well flow rate was ~ 1300 bwpd & ~ 20 bopd, natural free flowing.

Since the well was flown at a higher water rate than anticipated, the asset management believed there the completion had intercepted a fault that could be the cause for contributing the water volume.
The decision was made to run a horizontal production log to determine the phase contribution across the horizontal lateral and to diagnose if the lateral had cut through a fault or the completion connected to a fault network.

Tractor Deployment

The asset management staff was not directly involved in the deployment selection of neither the horizontal production log nor the deployment device. Due to deployment costs, the decision was made to deploy the production log tools into the wellbore with a wireline & well tractor setup.

The wireline & well tractor setup was dispatched on the job was a 3 1/8" OD well tractor approximately 20 ft in length deploying a horizontal production logging string 1 11/16" OD ~ 25 ft length.

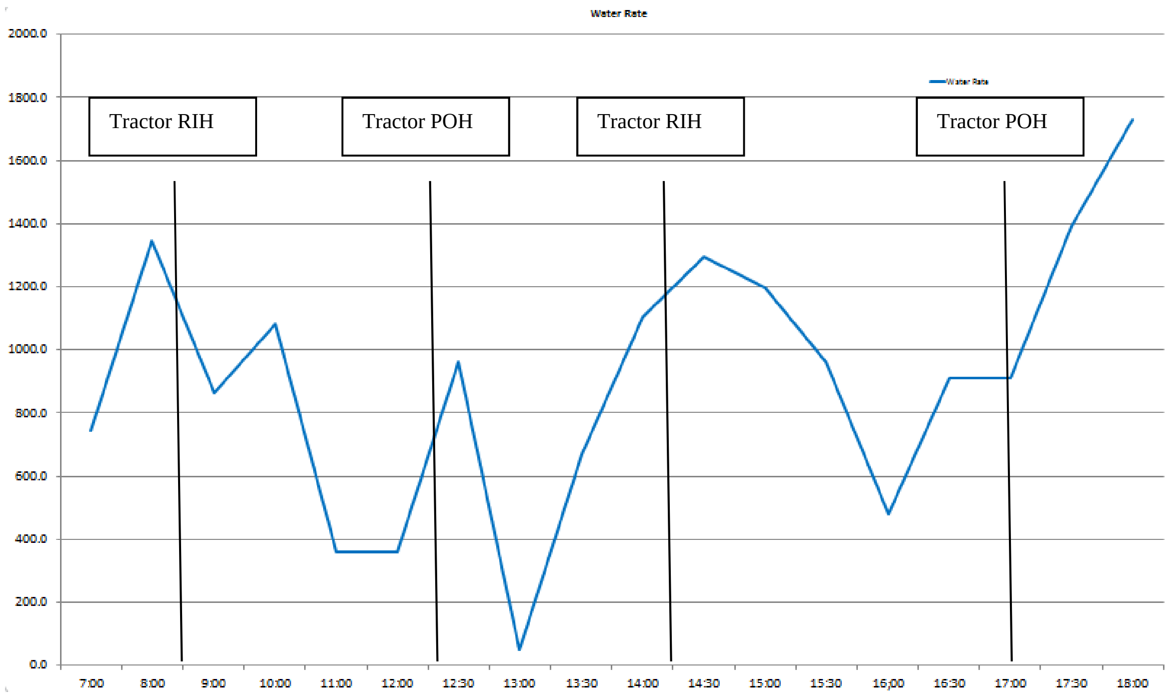
During deployment of the well tractor and horizontal production logging string, the well flow was affected and choked back causing flow instability. Table 1 lists the hourly flowback data as the Tractor deployed survey is conveyed. During the deployment of the well tractor the flowback at times was perturbed by 60% - 70% of regular flow rate. A second run was required as the well tractor was re-run & on the 2nd run the well perturbed (choked back) by ~ 50%.

Table 1. Well tractor deployed production log, flow back data

DATE m/d/y	**TIME 24 Hrs**	**CHOKE SIZE**	**TBG. PSI**	**CSG. PSI**	**WATER ACCUM**	**WATER BBL/D**	**OIL ACCUM**	**OIL RATE BBL/D**	**COMMENTS / REMARKS**
08/21/12	**6:00**	28/64	no tbg.	80	49.0		0.0	0.0	
	7:00	28/64	no tbg.	80	80.0	744.0	0.0	0.0	
	8:00	28/64	no tbg.	85	136.0	1344.0	0.0	0.0	
	9:00	28/64	no tbg.	85	172.0	864.0	0.0	0.0	RIH w/ MPL string under tractor @ 9:19
	10:00	28/64	no tbg.	90	217.0	1080.0	0.0	0.0	
	11:00	28/64	no tbg.	90	232.0	360.0	0.0	0.0	
	12:00	28/64	no tbg.	100	247.0	360.0	0.0	0.0	Out w/ MPL string and tractor @ 12:15
	12:30	28/64	no tbg.	100	267.0	960.0	0.0	0.0	
	13:00	28/64	no tbg.	95	268.0	48.0	0.0	0.0	
	13:30	28/64	no tbg.	80	282.0	672.0	0.0	0.0	
	14:00	28/64	no tbg.	70	305.0	1104.0	0.0	0.0	RIH w/ MPL string under tractor @ 14:13
	14:30	28/64	no tbg.	70	332.0	1296.0	0.0	0.0	
	15:00	28/64	no tbg.	70	357.0	1200.0	0.0	0.0	
	15:30	28/64	no tbg.	70	377.0	960.0	0.0	0.0	
	16;00	28/64	no tbg.	70	387.0	480.0	0.0	0.0	
	16:30	28/64	no tbg.	70	406.0	912.0	0.0	0.0	Out w/ MPL string and tractor @ 16:45
	17:00	28/64	no tbg.	70	425.0	912.0	0.0	0.0	
	17:30	28/64	no tbg.	70	454.0	1392.0	0.0	0.0	
	18:00	28/64	no tbg.	70	490.0	1728.0	0.0	0.0	

Figure 1. Illustrates the effects of deployment versus flow rate when deploying the well tractor into a flowing wellbore.

Figure 1. Well tractor deployed production log, flow back data

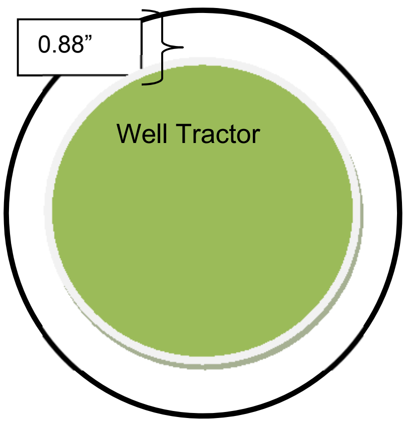


Casing & Tractor Specs

- 5 ½ " 17 # Casing ~4.892" ID; Area ~ 75.18 sqinch
- Tractor Closed OD ~ 3.125; ; Area ~ 30.68 sqinch
- Tractor length is 20 ft
- Clearance ~ 45.1 sqinch ~
- Wheels Open < 45.1 sqinch

Figure 2 illustrates the clearance & flow area between casing wall & 3 1/8" well tractor ~ 0.88".

Figure 2. Casing & Tractor position in wellbore



Coiled Tubing Deployment

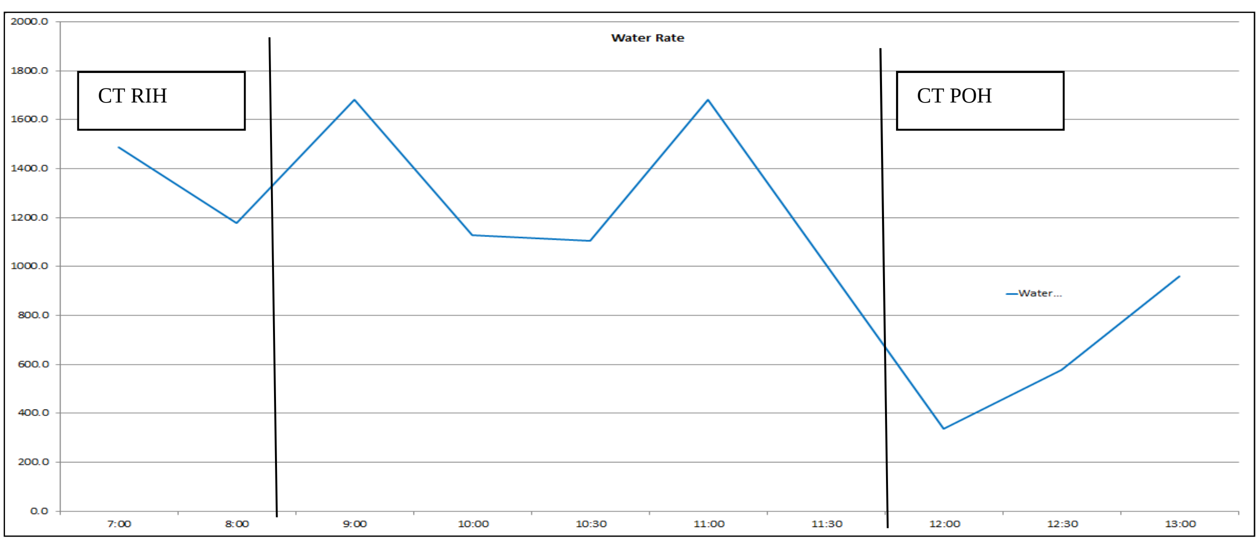
The deployment of the well tractor was unsuccessful in reaching the desired depth for the production log to be effective, the decision was then made to re-deploy in the well using a 2'" Coiled Tubing (CT). On the initial run the CT was used to clean out the well & make a through cleanout trip/dummy run.

During deployment of the CT and horizontal production logging string, the well flow had slightly affected the flow & did cause some choking conditions. Table 2 lists the hourly flowback data as the CT deployed survey is conveyed. During the deployment of the CT the flowback at times is perturbed by 30%. Figure 3. Illustrates the changes in surface rates as the CT is deployed across the lateral.

Table 2. Coiled Tubing deployed production log, flow back data

8/24/12	6:00	35/64	no tbg.	100	58.0		0.0	0.0	
	7:00	35/64	no tbg.	100	120.0	1488.0	0.0	0.0	
	8:00	35/64	no tbg.	100	169.0	1176.0	0.0	0.0	RIH w/ memory prod. Logging string on 2" coil tbg.@ 8:10
	9:00	35/64	no tbg.	100	239.0	1680.0	0.0	0.0	
	10:00	35/64	no tbg.	100	286.0	1128.0	0.0	0.0	
	10:30	35/64	no tbg.	100	309.0	1104.0	0.0	0.0	
	11:00	35/64	no tbg.	100	344.0	1680.0	0.0	0.0	
	11:30	35/64	no tbg.	100	365.0	1008.0	0.0	0.0	
	12:00	35/64	no tbg.	100	372.0	336.0	0.0	0.0	Finished w/ logging passes @ 12:47
	12:30	35/64	no tbg.	100	384.0	576.0	0.0	0.0	
	13:00	35/64	no tbg.	100	404.0	960.0	0.0	0.0	

Figure 3. Coiled tubing deployed production log, flow back data



Casing & Tractor Specs

- 5 ½ " 17 # Casing ~4.892" ID; Area ~ 75.18 sqinch
- CT OD ~ 2"; ; Area ~ 12 sqinch
- Clearance ~ 63.2 sqinch ~
- If an over gauged BHA is used 2 7/8" the clearance ~ 49.8 sqinch
- In reality CT would create a decentralized affect which allows for a maximum 2.892" flow area.

Figure 3 illustrates the clearance & flow area ~ 1.44" & Figure 4 illustrates the clearance & flow area ~ 2.892" is how the CT is run in a well bore decentralized along the lateral section.

Figure 3. Casing & Coiled Tubing (Centralized) position in wellbore

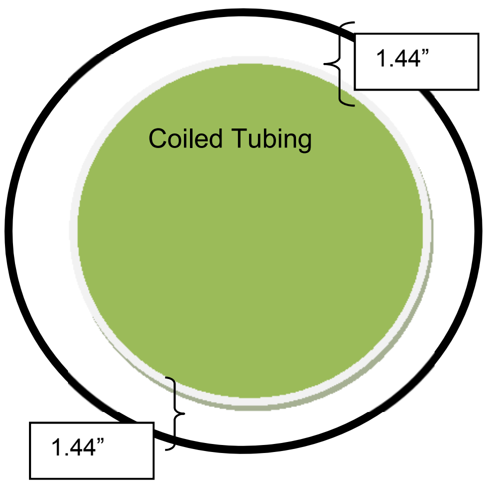
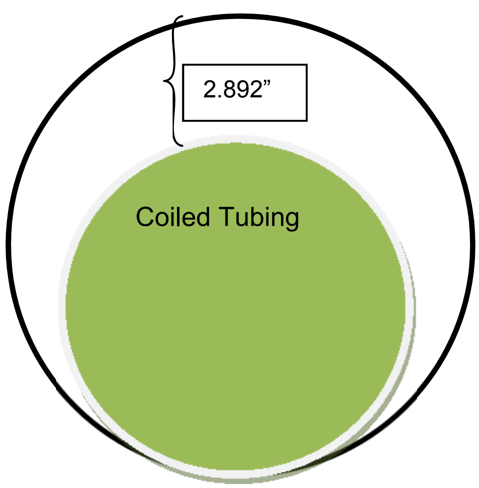


Figure 4. Casing & Coiled Tubing (Decentralized) position in wellbore



Production Logging Tool Configuration

A production log is required by oil company engineers to measure flow contributions in a wellbore and to identify zonal contribution of water & hydrocarbons for reservoir & production engineering calculations (Heddleston, 2009). A typical production log tool configuration run has an internal diameter of 1 11/16" OD and the tools are rated to 350 deg F & 15,000 psi.

The tool measurements consist of;

- Gamma Ray
- Casing Collar Locator
- Pressure Sensor
- Temperature Probe
- Fluid Capacitance
- Fluid Density
- Holdup
- Resistivity Array
- Spinner Array
- Bottom Flowmeter

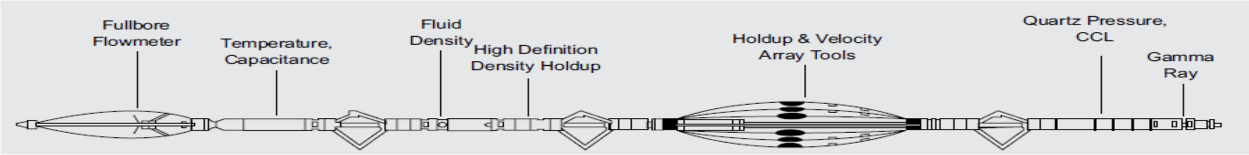


Figure 5. Horizontal Production Logging String.

Due to the comingling effect of fluids in a vertical wellbore, a standard vertical well production log survey only requires 1 or 2 fluid identification sensors which would be a capacitance, density & holdup measurement with a standard flowmeter. The fluids comingle together upon entering the flow area & the production log fluid ID sensors are required to measure & determine the holdup (phase fractions) in the flow area.

When it comes to horizontal well flow traditionally once the fluids enter the lateral the fluids (gas/oil/water) will begin to stratify. This means the heavy fluids will settle to the bottom of the lateral flow area, oil then gas will each create their own layer on top of each other. All phases flow at their own speeds relative to each phase & depending on the lateral trajectory the phases will increase & decrease in velocity as the trajectory increases or decreases. Fluids also can settle into low spots in the lateral & lighter phases will flow across this fluid trap causing velocity changes. Therefore, a multi-sensor array tool platform is ideal to measure the different velocities of each fluid as the sensors pass each perf interval.

The multi-sensor array measurements places discreet individual probes circumferentially across the cross section of the wellbore to measure the flow in each section or slice across the cross section, as shown in Figure 6. Multi-sensor spinner measurements will measure the velocity of each phase & a multi-sensor fluid identification measurement will measure the difference between a dialectic fluid properties or a resistivity of the different phases.

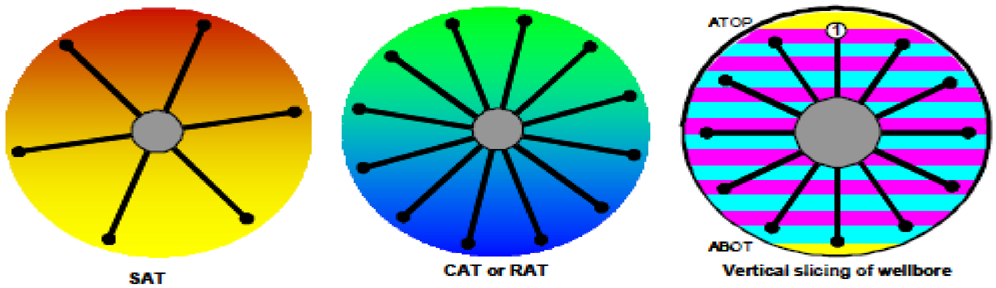


Figure 6. Array sensor positions in wellbore (Frisch, Dorffer, Jung, 2009).

Case History Horizontal Production Log Results

On this particular well the customer encountered a high water influx flow problem. The well was free flowing close to 2000 bwpd & a trace amount of oil volume. As discussed above the flow rate during deployment was not stable with the each deployment method used; however the deployment method least affecting the flow in this particular case history was with the CT deployment.

The parameters of the well is a staged fraced well with 14 stages; this was a hook shaped lateral eventual ending with a toe down trajectory as illustrated in Figure 8.

The well flow rate was approximately 99% water contribution from ~1800 bwpd to 2000 bwpd in the free flowing state.

Results

The production log results are represented in Table 3. The toe stage 1 and stage 4 accounts for ~57% of the total water flow ~ 667 bwpd.

Table 3. Well stage contribution results.

STAGE	WATER BBLD	WATER %
14	58	5%
13	0	0%
12	62	5%
11	8	1%
10	41	4%
9	110	9%
8	51	4%
7	41	4%
6	132	11%
5	0	0%
4	344	29%
3	0	0%
2	0	0%
1	323	28%
TOTALS	1170	100%

The oil company engineers determined that the production log confirmed that 2 faults were penetrated during the completion. The area seismic processed data initially did not locate these faults. Upon further analysis & reprocessing the faults were identified.

The customer set a plug above stage 4 & shut off 50% of the water & the well came back to flow ~ 100 bopd.

Figure 7. is an illustration of the production log results on this case history showing the respresentative flow rates contributing across the lateral.

The water rate shut off with remediation actually reflects closely to the production log results. The results are greatly influenced by the deployment method & can by conveying deployment devices affecting flow can call into question the validity of the results.

Since the remediation results closely matched the Indepth Production Solution log analysis, this can correlate to the deployment method used that worked the best to limit the amount of perturbation of the flow.

Figure 7. Well Production Log Results

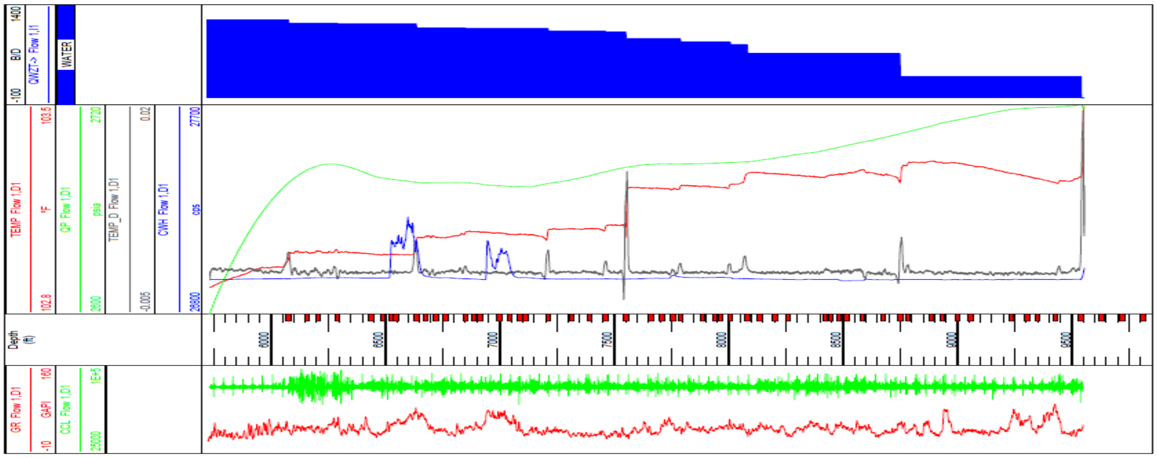
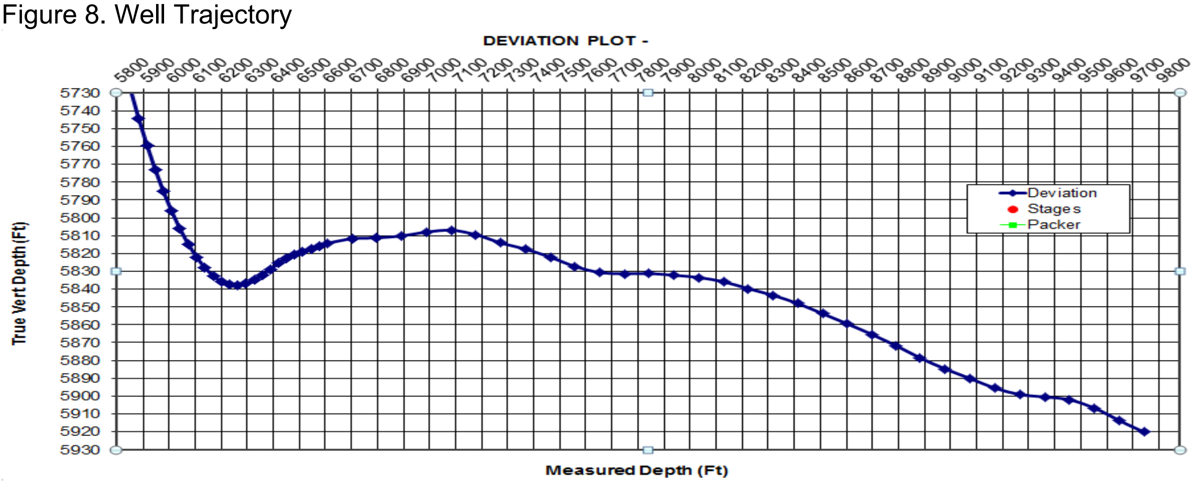


Figure 8. Well Trajectory



Conclusion

In order to acquire the best quality results & a representative flow profile in a horizontal well, engineering buyers should focus not only logging tool technology & how the logging provider can deliver quality results, but they also should be focused on ordering the best deployment method that can limit the choking effects when deployed across a flowing lateral. By eliminating flow perturbation will assist in delivering the most representative well flow results.

Most deployment companies are unfamiliar with a production log end results & how the technology measures & what can cause issues when processing the data. Therefore, the deployment company may not be able to advise what the best product to deliver the best results to the buyer The oil company buyer should view the horizontal production log as a science project where both the deployment company and logging provider meet to discuss operational requirements.

This communication will help to deliver the proper results sought after & eliminate any additional uneccssary costs to the buyer.

About the Author

Duncan Heddleston P.E. MBA Marketing
Mr. Heddleston is a regarded leader in production logging & production log analysis and has been involved in the wireline logging product line since 1992 with industry leading international service companies. Mr. Heddleston is a global consultant for oil companies & service companies' assisting on numerous log data sets per year. Mr. Heddleston has extensive experience deploying, measuring & analyzing vertical & horizontal production & reservoir data sets & he has pioneered numerous logging techniques throughout the world.
Mr. Heddleston is a P. Eng. and holds a B.Sc. in Petroleum Engineering from the University of Albert & he also holds a MBA in Marketing.

References

Frisch, Dorffer, Jung 2009 Improving the Process of Understanding Multiprobe Logging Tools from the Field to Final Answer, paper presented at SPE Annual Technical Conference and Exhibition held in New Orleans, Louisiana, USA, 4-7 October 2009.

Heddleston 2009 Horizontal Well Production Logging Deployment and Measurement Techniques for US Land Shale Hydrocarbon Plays, paper presented at SPE Production and Operations Symposium held in Oklahoma City, Oklahoma, USA, 4-8 April 2009.