Combining and Customizing Technologies for Perforating Horizontal Wells in Algeria

MENAPS-11-15

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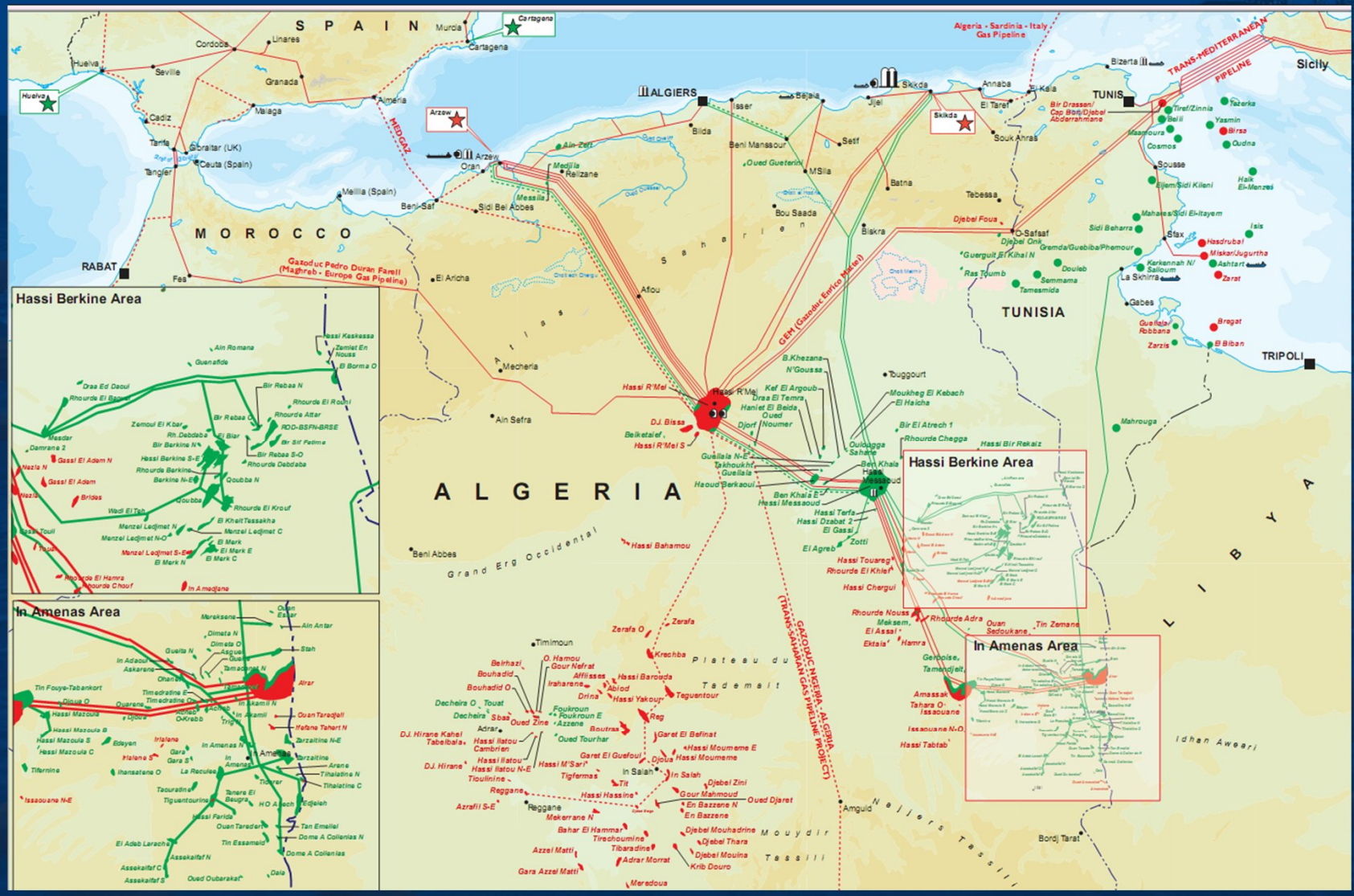
AGENDA

- Field location
- The QB-XX Horizontal Well Completion
- Horizontal Well Perforation Techniques
- Perforation Orientation in Horizontal wells
- Job Preparation and deployment
- Dynamic Underbalance
- Production log
- Conclusions

Hassi Berkine Basin Location



Ourhoud Field

- The Ourhoud field is located in the Hassi Berkine basin on the eastern side of central Algeria, discovered in June 1994
- It is the second largest oil field in Algeria covering an area of 150 km²
- The field produces from the Shaly-Sandstone, lower TAGI formation, at an average depth of 3,200 m
- Pressure support is by means of water and gas injection
- All wells are vertical except for QB-XX which is horizontal as a pilot and completed in gas injection region of the reservoir
- Objectives of QB-XX horizontal drilling is to minimize water encroachment and consequently salting up the well.

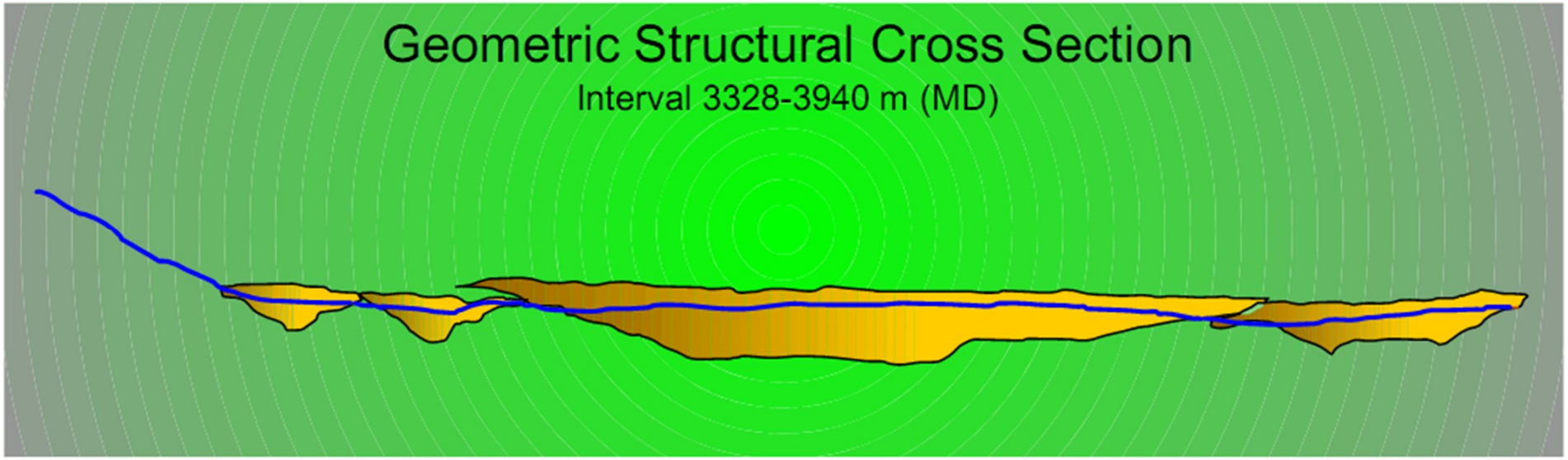
QB-XX Completion

The well was completed using cemented liner

Objectives were to:

- Selective perforation
- Avoid low pressure and high saturation intervals which could jeopardize the production profile
- Optimize production
- To being able to by passing future water encroached zones by shut off
- Orienting perforation away from OWC to delay associated water problems

QB-XX Cross section



Horizontal Well Completions

Horizontal Completion Methods

Horizontal Well Completion	Shaped Charge Perforating	Selection of productive intervals	Maintain Hole Stability	Allows Water Shut-Off
Open Hole	No	No	Depends (*)	Complicated
Slotted Liner	No	No	Yes	No
Cased and Cemented	Yes	Yes	Yes	Yes

(*)Depends on rock's compressive strength

Perforating in Cased Horizontal Wells

Gun Deployment, Cased and Cemented Horizontal Wells

Deployment of Guns	Rig Required	Depth Correlation Control	Oriented Perforating
Tubing Conveyed Perforating	Yes	Weak	Limited
Coiled Tubing Conveyed Perforating	No	Weak	No
Electric Line inside Coiled Tubing	No	Good	Yes
Tractor	No	Good	No

Perforating Horizontal Section with Electric Line Inside Coiled Tubing

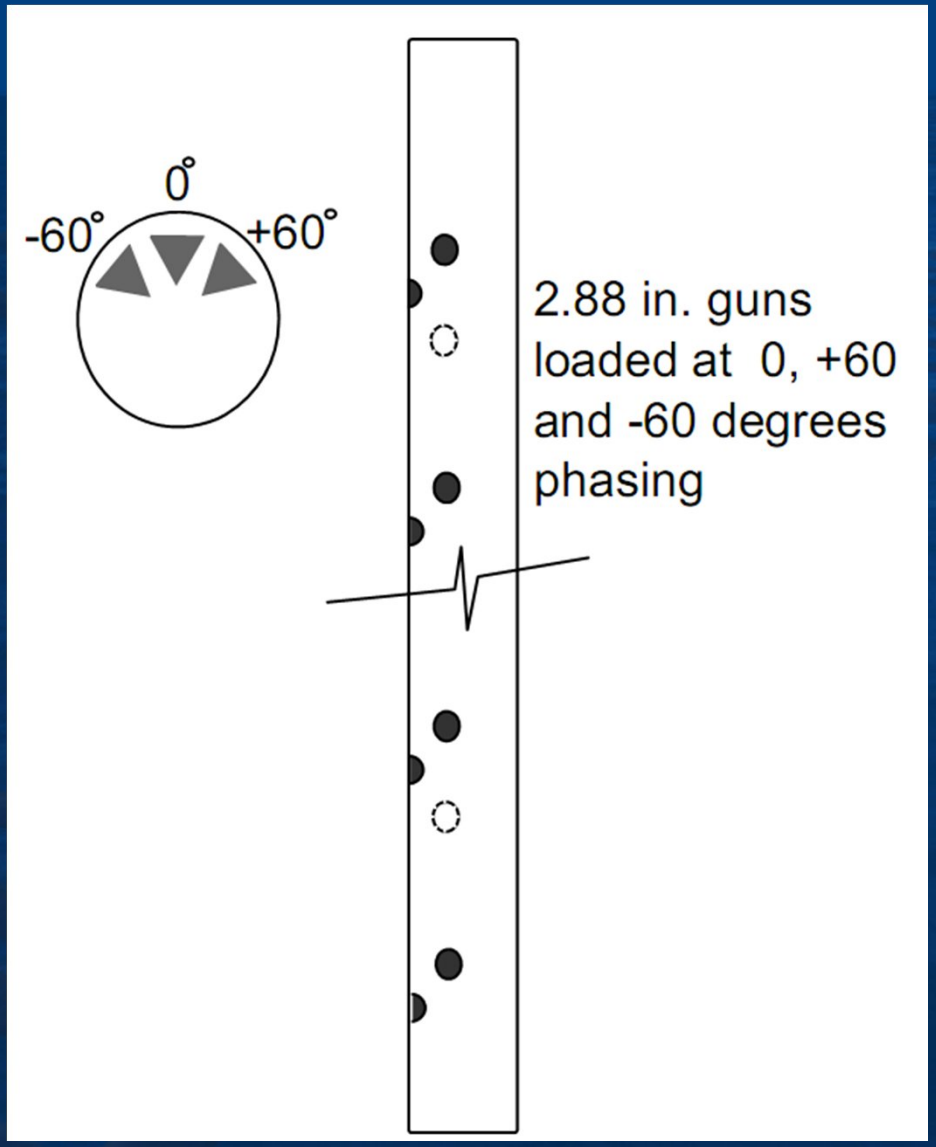
Advantages:

- Drilling or workover rig not required for the job
- Can be performed at any time of well life
- Addressable switches can be used for selective perforation
- Number of guns can be optimized by evaluating the tubing forces using proprietary software
- Special rollers were placed on the gun string to overcome friction due to tubing and gun weight.

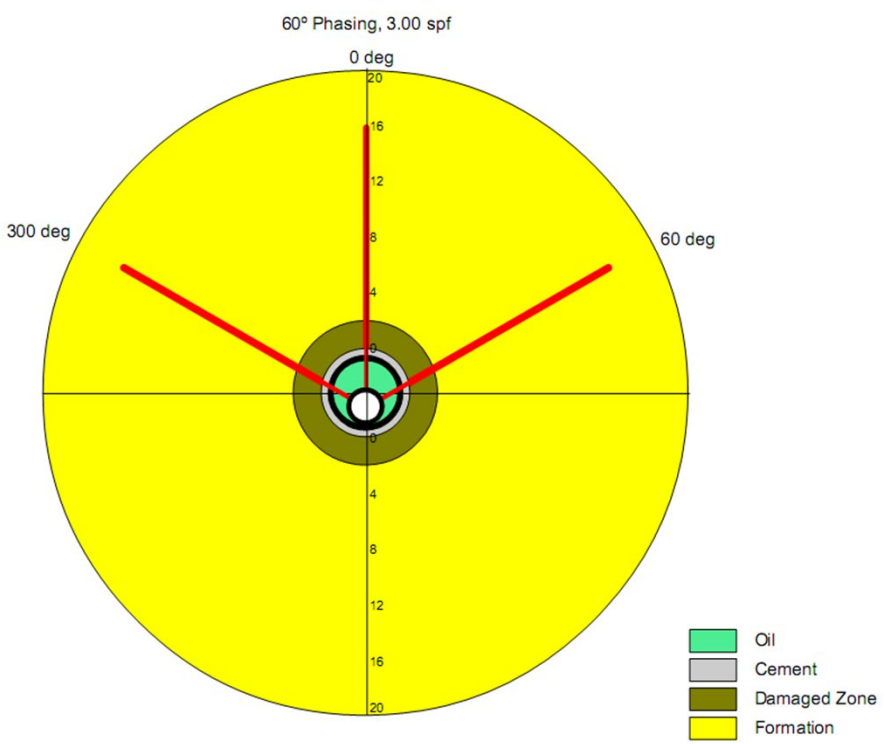
Job Preparation

- Petrophysical analysis to properly selecting the interested intervals
- Zones of higher water saturation and permeability greater than 1 darcy were avoided
- Select the gun design to face upward well direction to avoid well salting and debris fall down to the bottom perforation in case of 360deg perforating, as well as delaying water breakthrough
- A 2 7/8” HSD gun was chosen to perforate 4 ½” casing and loaded at +60, 0, and -60 deg

Job Preparation - 2 7/8” gun loading Configuration



Job Preparation - SPAN Analysis



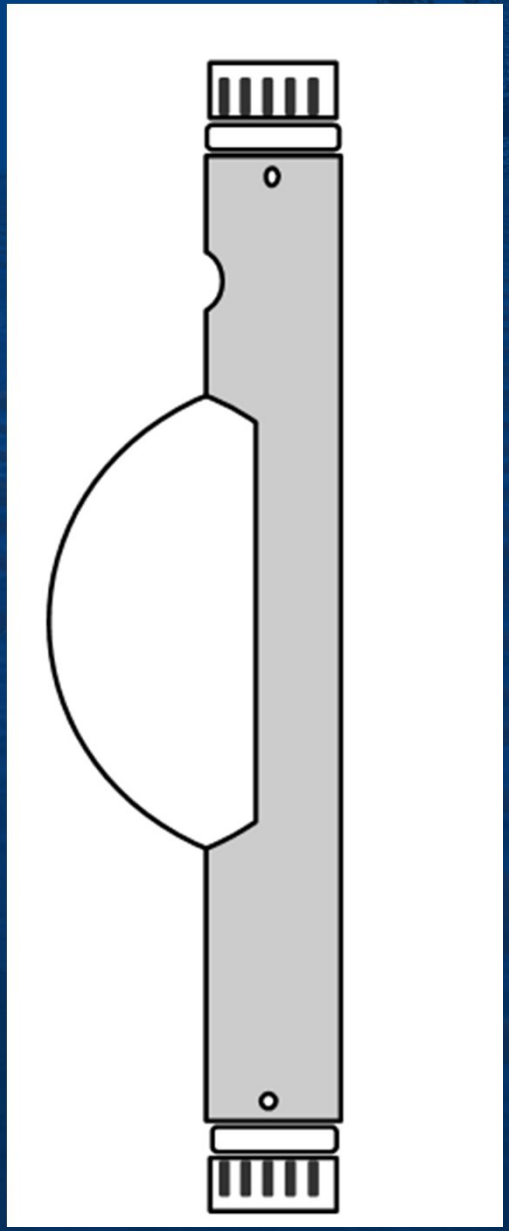
Angle (deg)	Clearance (in)	Total Pen (in)	Form Pen (in)	Form Dia (in)	Csg EH Dia (in)
0	1.98	16.77	15.91	0.41	0.23
60	1.32	17.38	16.52	0.50	0.28
300	1.32	17.38	16.52	0.50	0.28
Average	1.54	17.18	16.32	0.47	0.27

API: Pen 36.00 in, EH Dia 0.34 in, Based on 19B 1st Ed.

AOF (in²/m) 0.53 at 3.00 spf

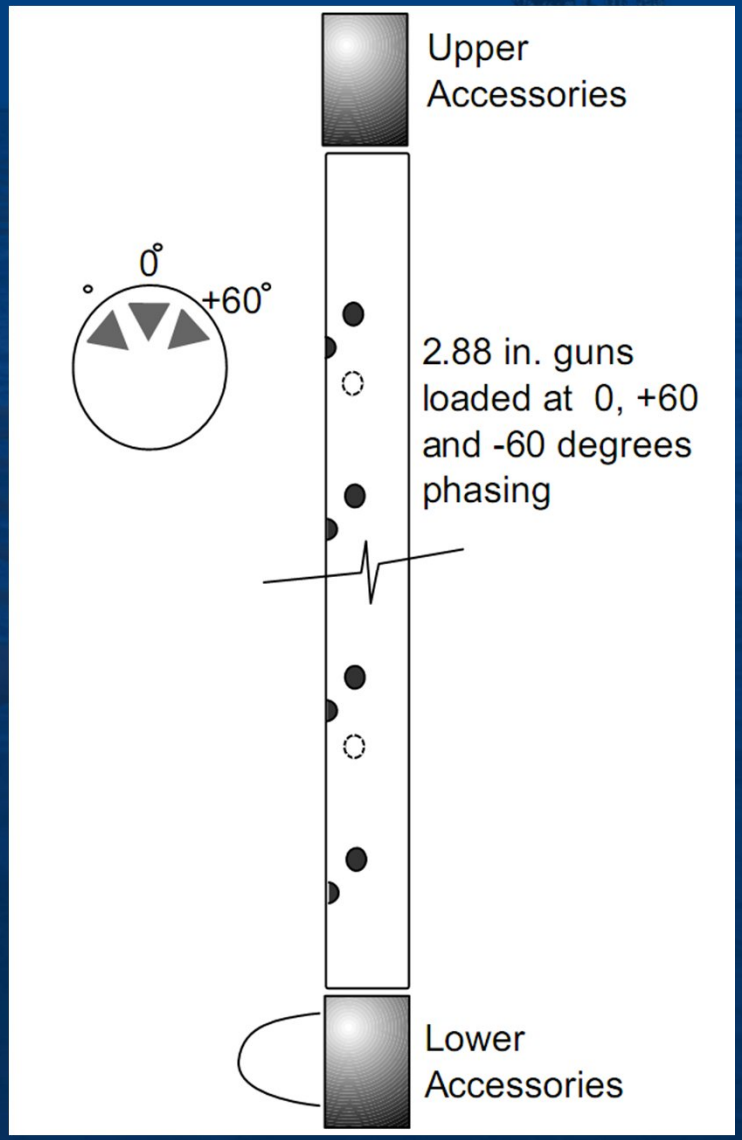
Job Preparation - Eccentralizer Bow

The eccentralizer in which the steel bow strip pushes the tool in favor of gravity, and therefore, once the 0º phasing charge was aligned with the same bow direction, it was guaranteed that the other two shots (+60º and -60º) were also aligned to the upper section of the horizontal direction.



Job Preparation - Each gun section schematic

- By using swivels and eccentralizer, the job was completed with the guns pointing upward in the horizontal section (in a 0º, +60º and -60º phasing loaded with 3 spf)
- The premium deep penetrating shaped charges, dynamic underbalance, and detonators that do not require radio silence, were additional newly introduced perforating technologies used in this job.



Job Preparation - Addressable switches

- For selective gun firing in long intervals with spacing
- Reduces the spacers required
- Enable running until 40 guns
- Reduces number of runs which consequently reduces rig time

Gun string deployment

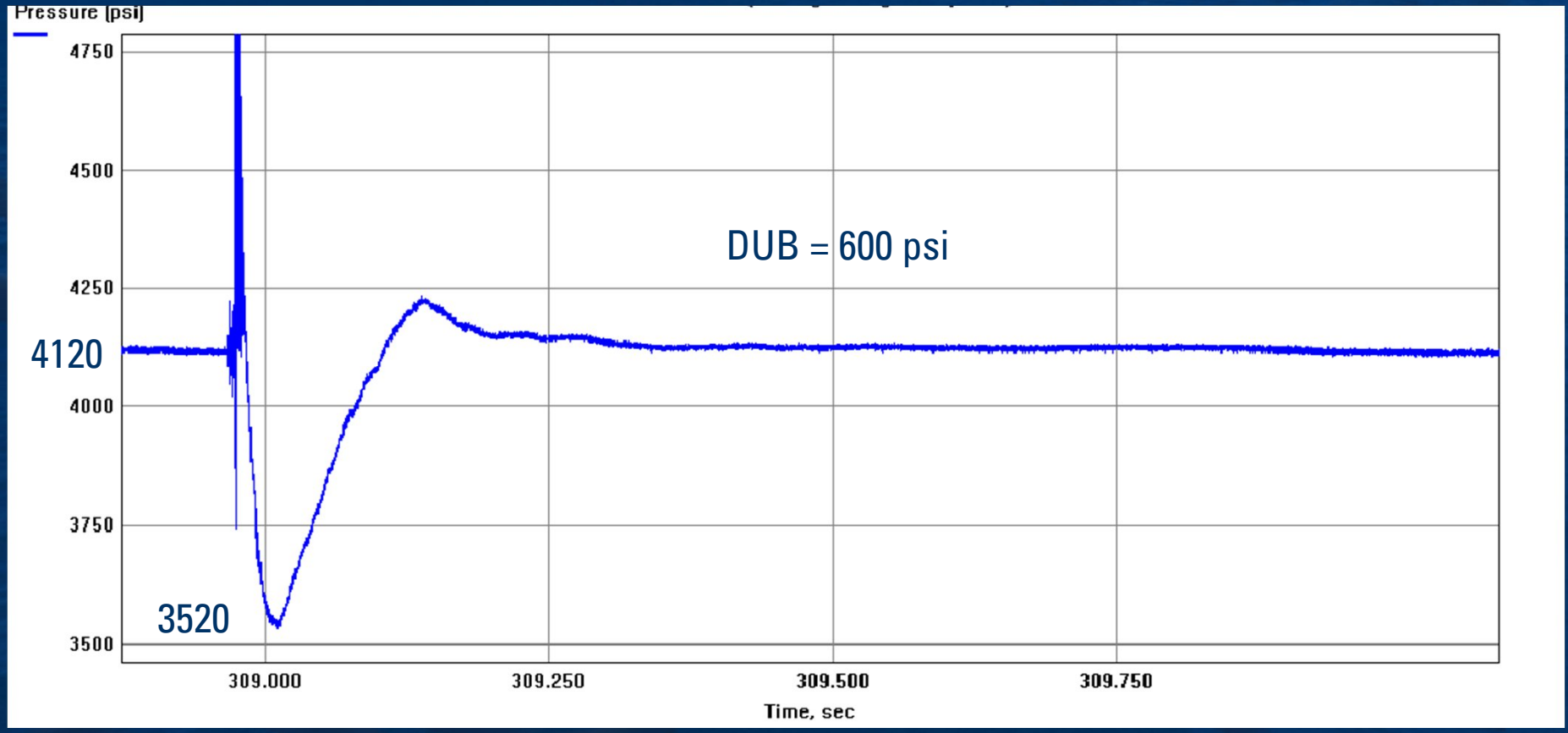
- Well was live with 1100 psi from old perforation a year ago
- Manufactured special deployment bars in order to deploy eight 6m guns in one descend
- 61m string deployed at each descend

Deployment Animation

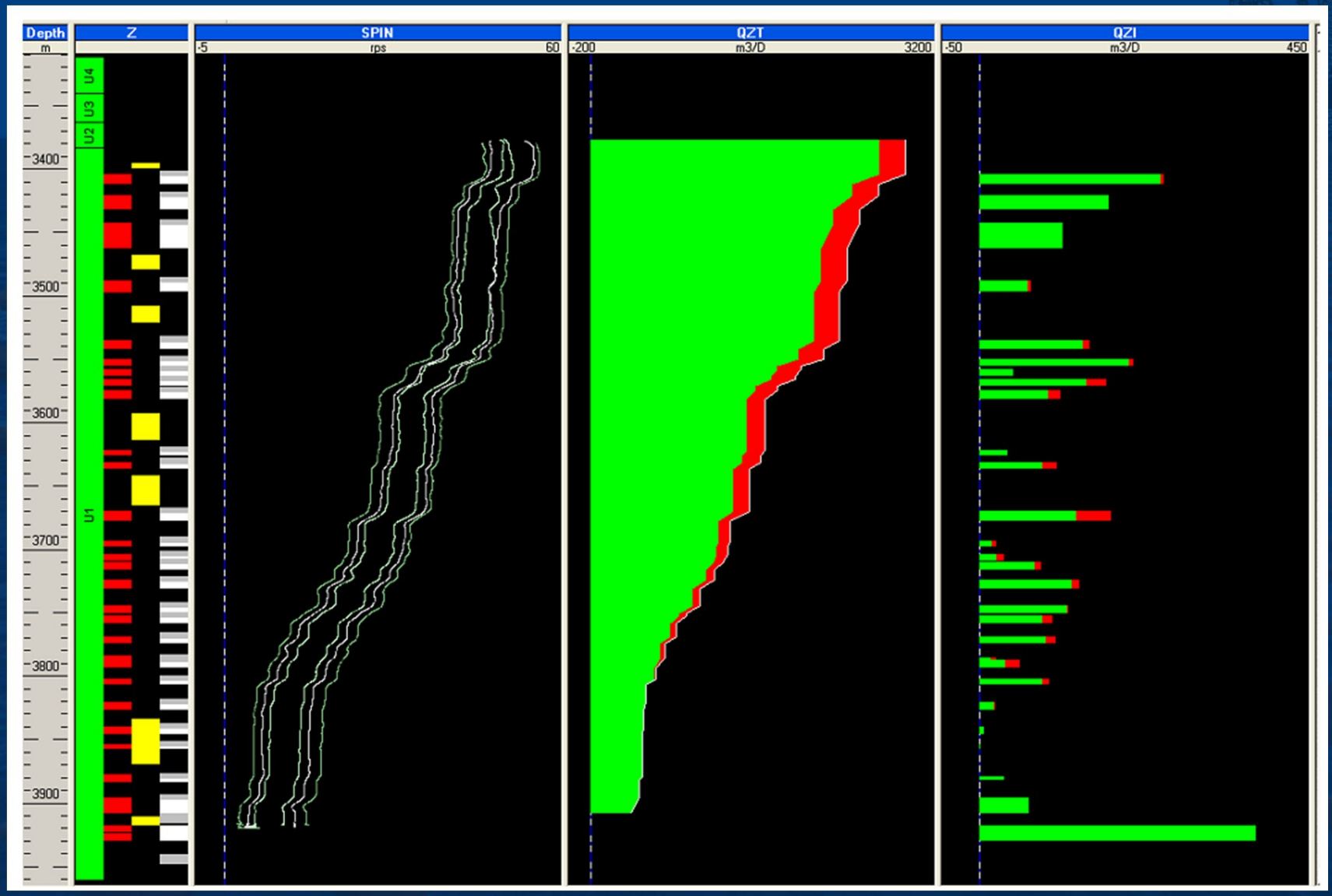
Dynamic Underbalance

- Dynamic underbalance was intended for post perforation clean tunnels
- The guns were configured using reservoir, rock and well bore information to design for a reasonable dynamic underbalance
- The 3 SPF achieved a proper DUB of about 600 psi
- Additional 450 psi underbalance created from flowing of the well while shooting

Dynamic underbalance from fast gauge



Post Perforation Productivity



Conclusions

- The method used and described in this presentation demonstrated that in a horizontal well, it was possible to perforate several small horizontal sections without the need of a workover or drilling rig,
- Allowing the well to flow while the perforating job was conducted and maintaining a depth correlation as accurate as a wireline job performed in a vertical well.
- The requirements to perforate only the upper side of the horizontal section and to create a dynamic underbalance so as to provide clean perforated tunnels and achieve good formation penetration were also met.