

**2000 ft Horizontal Perforation with
Retrieving Debris Design to Clean Out Hole
in Cased Hole Carbonate Reservoir**



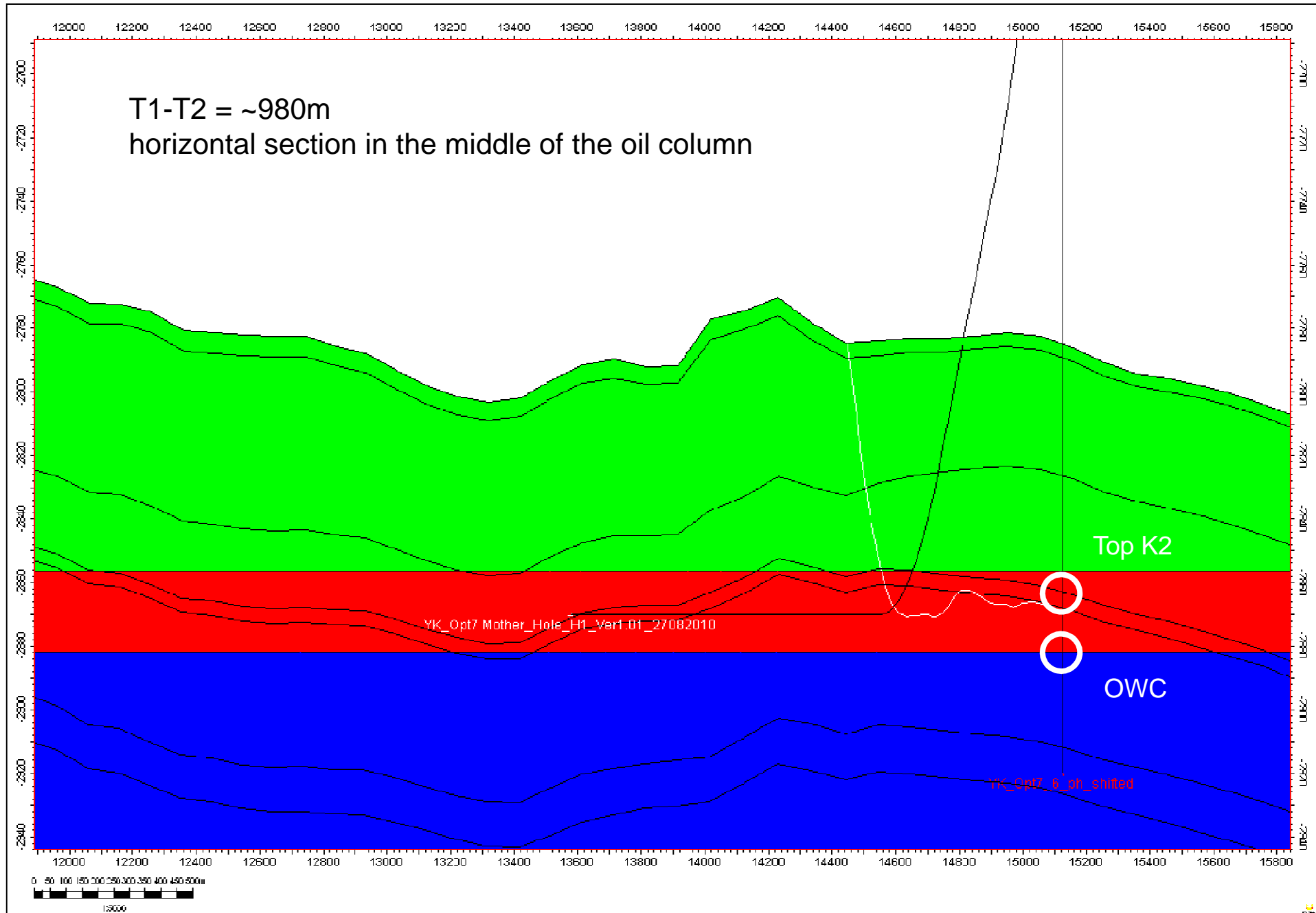
Retrieving Debris from Horizontal section

Well Objectives

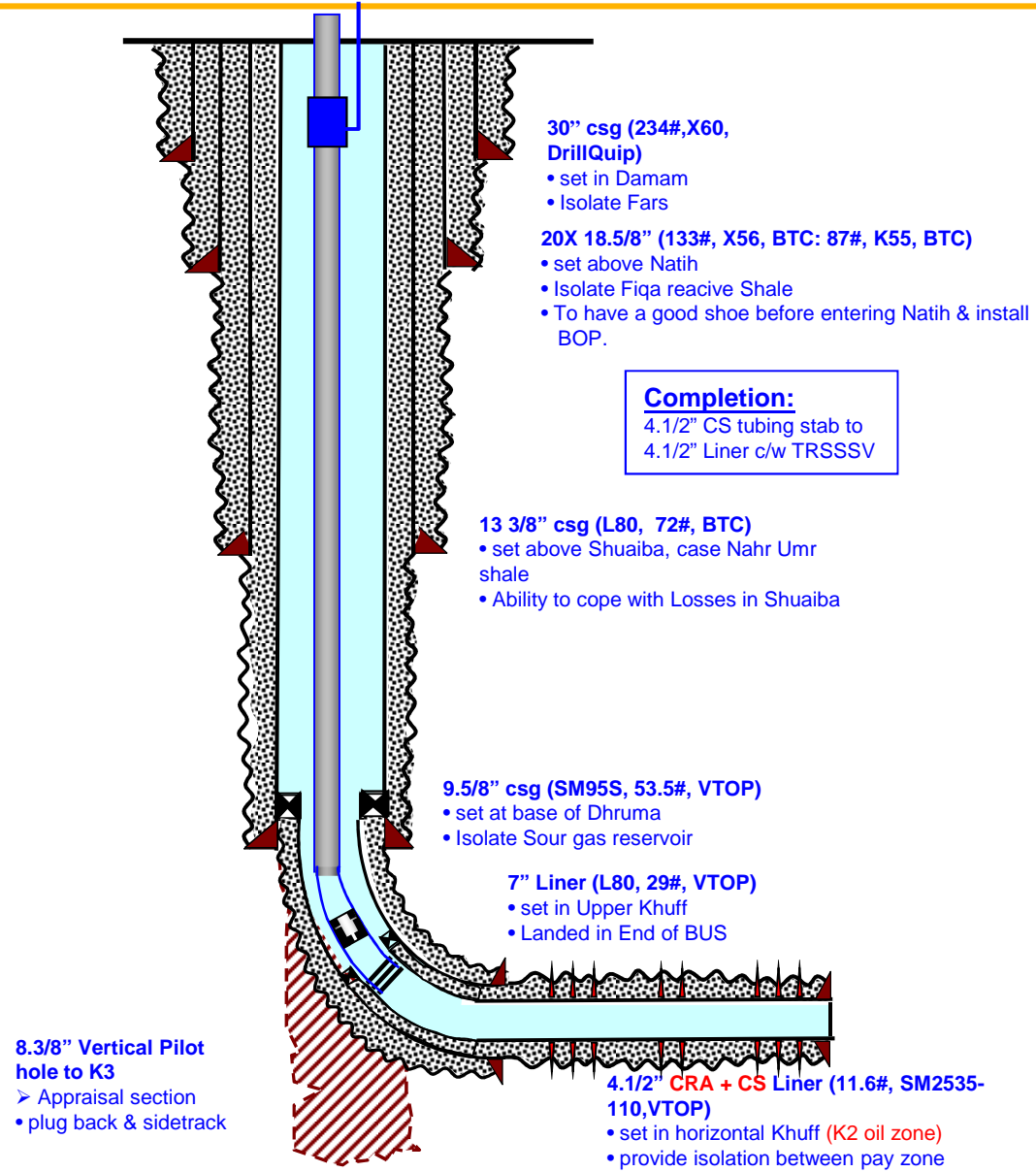
- Prove the "do ability" of horizontal wells to develop Khuff oil rim, in particular:
 - Drilling, completion, stimulation and testing of a long 1000 m horizontal drain.
- Evaluate the appraisal well result for field development.
- Perforate the carbonate matrix away from the fractures.
- Perforate Limestone using TCP and perforate Dolostone in live well using gun deployment technique.



Cross section Horizontal section



Horizontal/Appraisal Completion design



Retrieving Debris from Horizontal section

- **Challenges**

Challenges are high hydrogen sulphide (H₂S) up to ~5% (50,000 ppm).

Uncertainty of gun length based on geological prognosis.

Long blank gun section (approximately 50 % of net intervals).

Debris of perforating gun.

Recovery of this amount of debris is considered achievable.

Penetrating two fractured zones and uncertainty of achieving good cement along horizontal section.

- **Design**

Gun Type charges : 2.88” HSD 6spf , Deep penetration HMX

Extra deep penetration charges used in part of the well to compare results with premium deep penetration charges

Run rare earth magnet at the bottom of the gun assembly to recover all metal debris at the surface.



Design of Perforation Operations

- **Data Updates**

Gross perforation Interval Horz section :1187.16 meters

Net Perforation Interval :603.09 meters

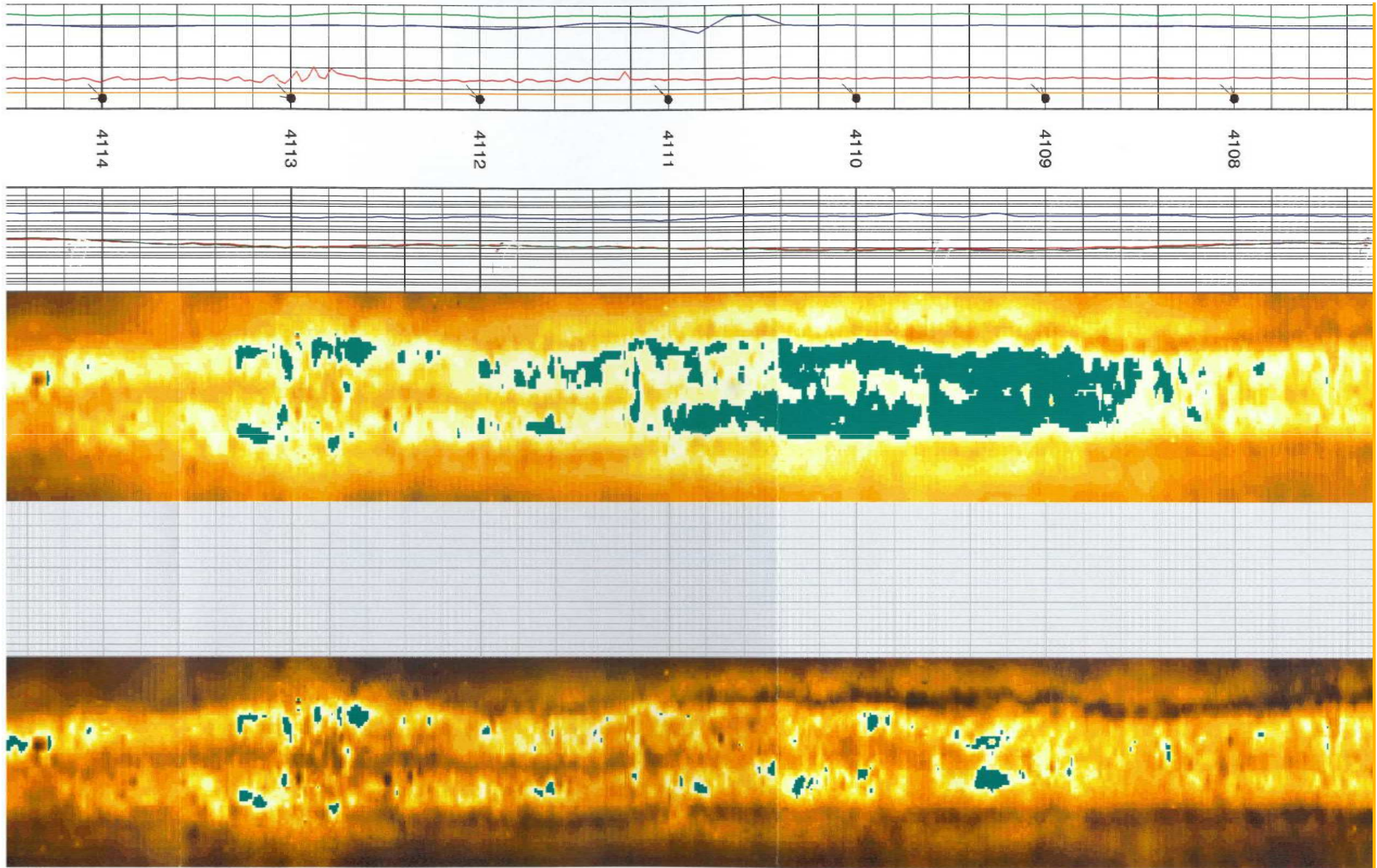
For 600 m debris of ca. 20-25 g/ft, with this a minimum ~50 kg was expected.

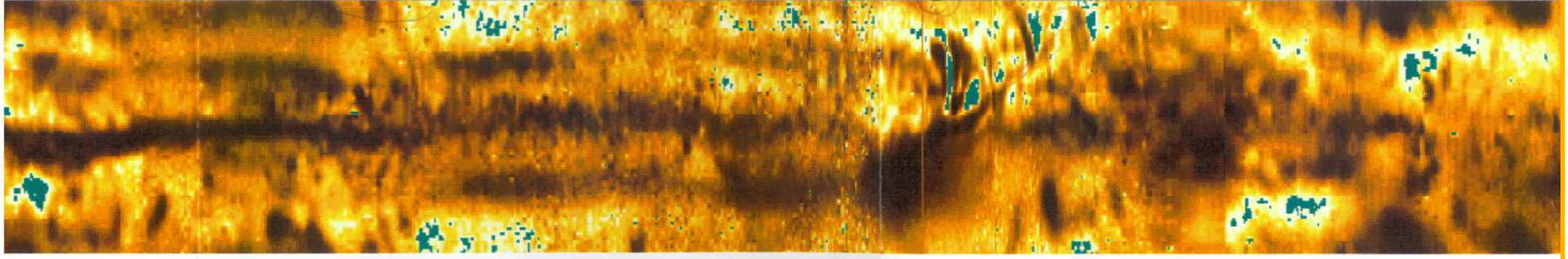
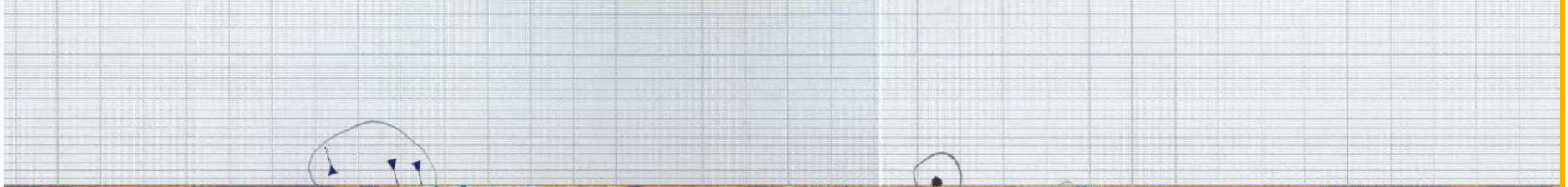
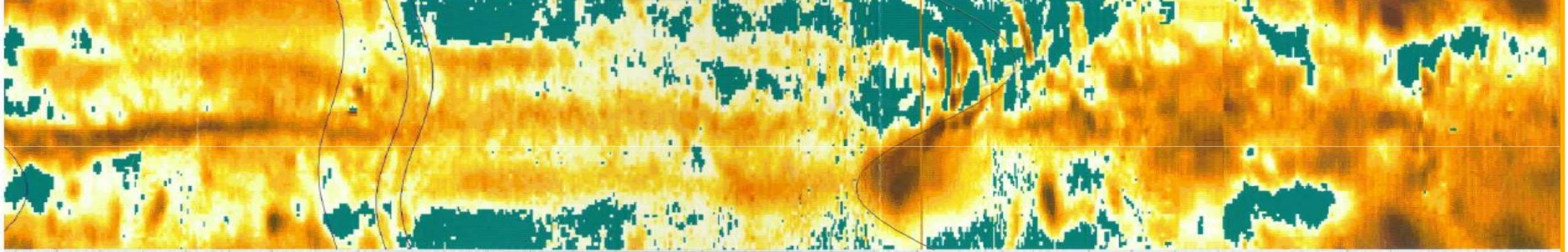
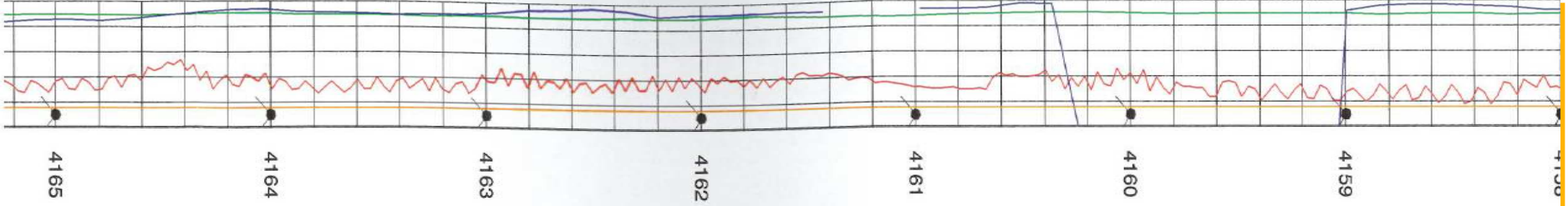
Recovery of this amount of debris is considered achievable.

No Dolostone formation has been encountered - no deployment required



FMI-DSI Log



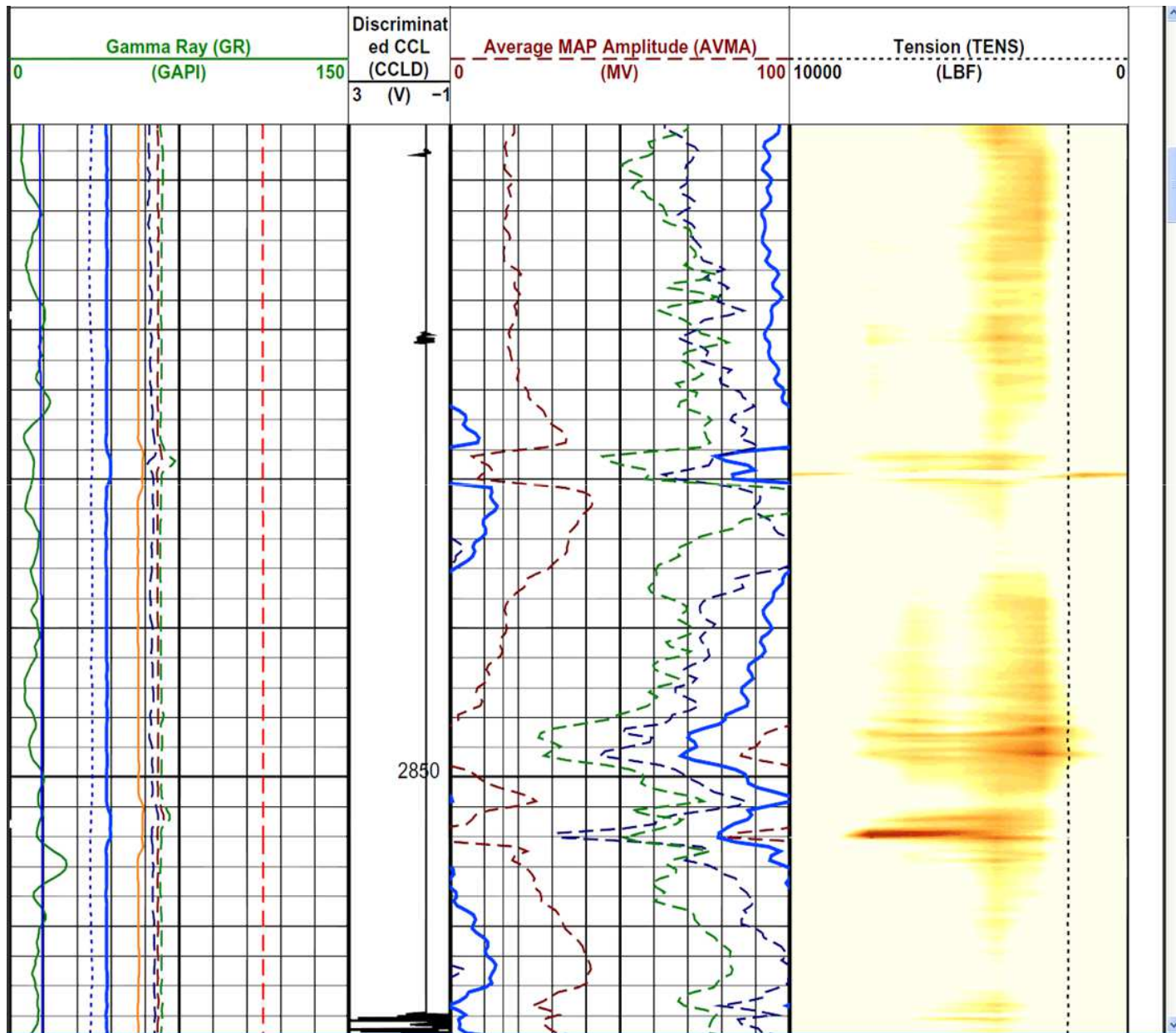


Assumptions

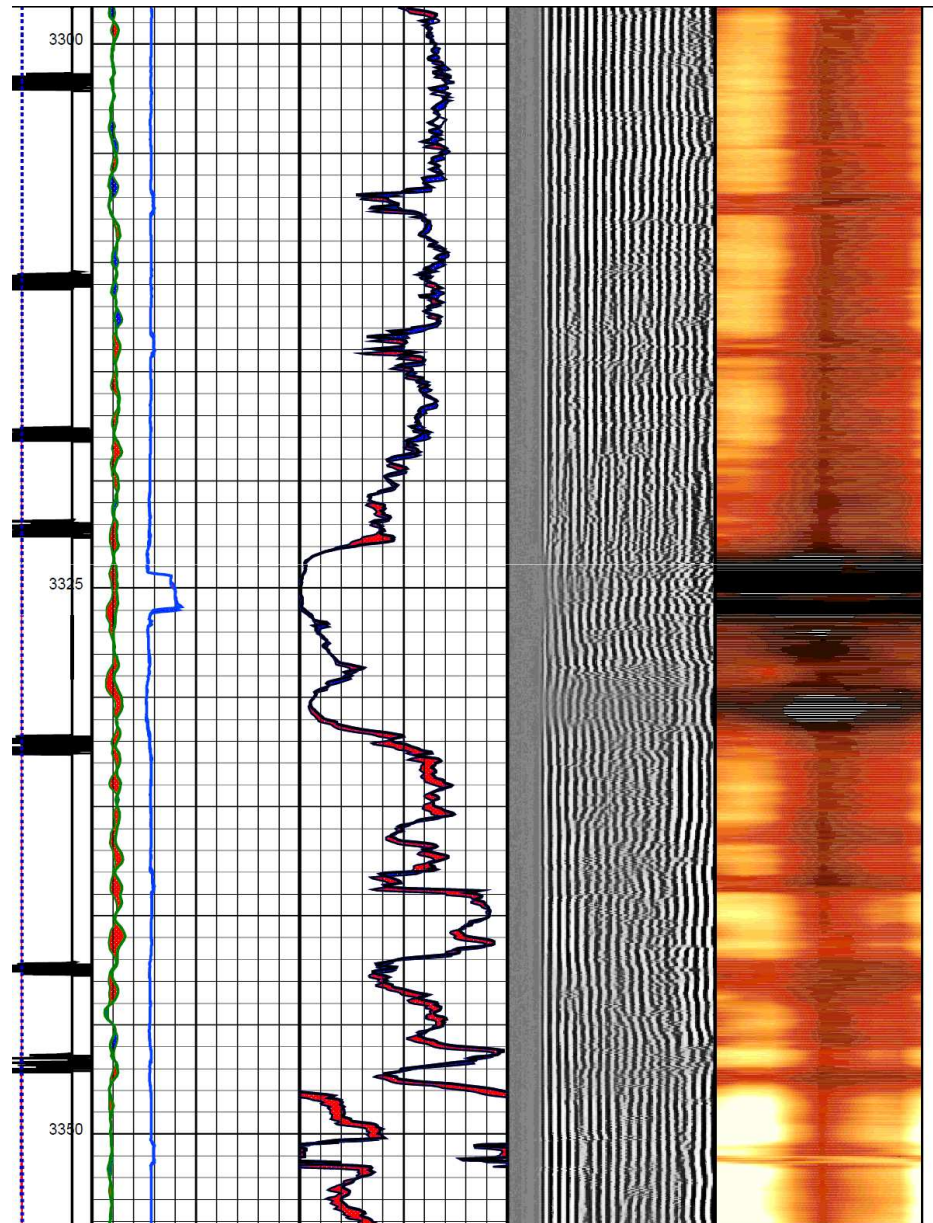
- From tests, gun debris could amount to 20-25 g/ft minimum (immediately after shot) or up to 210-275 g/ft maximum (possibly dropped while pulling out of hole) In practice, the debris left in hole will be somewhere between these extremes.
- For 600 m of guns 250 kg of debris is possible. Recovery of this amount of debris is possible but difficult. Considered low debris guns but no time to mobilise.
- It will be difficult to gauge how much debris is recovered inside the guns - they would need to be weighted before and after the job
- Plan to weigh the debris recovered on magnets and compare with repeated fishing runs to see how recovered debris is reducing.
- Careful pulling and handling of the fired guns should be done to help reduce the amount of debris falling out of the spent carriers.
- It is proposed to run magnet tool below the guns.



CMT Log



CBL/VDL Image Log



- One formation was encountered therefore one perforation job was revised.
- Log was carried out to select the perforated intervals away from fractures.
- Two charges have been selected for trial and comparison.
- 4 ½” liner was installed and cemented.
- CBL/Acoustic log was carried out and revealed poor cement behind 4 ½”.
- 2 7/8” gun was loaded as per last change. BHA was designed with 2 pup joints of magnets.





X-Over	4.50	2.2	3 1/2" EUE	2 7/8 HT PAC	0.40	2471.54	2471.94
2 7/8" HT PAC x 35 joints	2.88	2.44	2 7/8 HT PAC	2 7/8 HT PAC	336.00	2471.94	2807.94
X-Over	3.00	1.7	2 7/8 HT PAC	2 7/8" IF	0.40	2807.94	2808.34
⚠ R A Marker Sub ⚠	4.50	3.92	2 7/8" IF	2 7/8" IF	0.61	⚠ 2808.34	2808.95
X-Over	3.00	1.7	2 7/8" IF	2 7/8 HT PAC	0.40	2808.95	2809.35
2 7/8" HT PAC x 45 joints	2.88	2.44	2 7/8 HT PAC	2 7/8 HT PAC	432.00	2809.35	3241.35
X-Over	3.50	2	2 7/8 HT PAC	2 3/8" EUE	0.30	3241.35	3241.65
Pressure Operated Valve (POUV)	3.63	1.88	2 3/8" EUE	2 3/8" EUE	0.65	3241.65	3242.30
HDF / HDF-DA Redundant Firing Head	2.88	****	2 3/8 EUE	2 1/2 API	2.50	3242.30	3244.80
2.88" TCP Gun Safety Spacer	2.88	****	2 1/2 API	2 1/2 API	5.20	3244.80	3250.00
2.88" TCP Gun	2.88	****	2 1/2 API	2 1/2 API	750.00	3250.00	4000.00
2.88" Gun Bottom Nose.	2.88	****	2 1/2 API	****	0.17	4000.00	4000.17
X-Over	3.00	1.7	2 3/8" EUE	2 7/8 HT PAC	0.40	4000.17	4000.57
3 X Magno Sweeps	3.50	1	2 7/8 HT PAC	2 7/8 HT PAC	4.48	4000.57	4005.05



Debris removing toll before the Perforation Job



Debris removing after the Job



Debris recovery

- **4 KGS of debris was recovered and weighted at site.**
- **Lab test showed 100% metal for the sample.**
- **One KG was collected after clean out trip at shale shaker.**
- **Debris can be located in the gun, hole and perforated tunnel.**
- **Magnet retrieved debris only in the bore hole.**



Current Operations

- DTS was run to get basic temperature log.
- Record temperature log while pumping acid to determine injection profile across perforated intervals.
- The well was opened to production after acid stimulation and produced 2800 bpd and 5800 bpd on 16 and 64” choke.
- The well is currently shut-in for build up period.
- Data is under process to evaluate the production contribution from individual perforated intervals.
- Finger print for the debris sample will be carried out to check sample sources.



Conclusion and Recommendation

Conclusion and Recommendation

- Debris in long perforated intervals should be highly considered in perforation design.
- Clean out trip with mechanical and/or chemical should be considered.
- Magnet cannot retrieve debris inside perforated tunnel therefore tunnel cleanout should be designed using Dynamic Underbalance.



Thank you

Questions?



Gun Details

• Gun Type charges	:	2.88” HSD 6spf, Powejet 2906 HMX
• Firing System head, Redundant System)	:	3.06” HDF/HDF (Hydraulic Delay Firing
• Gross perforation Interval	:	1187.16 meters (Done in one run)
• Net Perforation Interval	:	603.09 meters
• Total Spacer Length	:	584.07 meters
• Total Number of Shots	:	11,872 shots
• Top Perforation Depth (MD)	:	3349.74 Mahbdf
• Bottom Perforation Depth (MD)	:	4527.00 Mahbdf
• Number of Interval	:	17 intervals
• Fluid Type / Weight used	:	Brine / 11.8 kPa/m
• Depth Control Method	:	Wireline Correlation
• Packer depth (MD)	:	2382 Mahbdf
• Rig Type	:	Land Rig
• Liner Size/Weight	:	4.5” 11.6 ppf
• Perforation Design Type	:	Overbalanced
• Deviation at Gun Section	:	91 DEG
• Total Operating Time (Rig up to Rig Down)	:	84 Hours (3.5 Days)

