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DTS vs. PL Case Study

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- DTS Overview
- Case Study 1 Production Logging & DTS Surveys
 - 8 hour DTS survey
 - PL surveys on all wells on pad
- Case Study 2 DTS in top producing wellbore
 - 25 hour DTS survey
- Conclusions

DTS Overview



Distributed Temperature Sensing (DTS)

The System measures temperature along the entire length of a fiber optic cable.



Smolen, van der Spek, Distributed Temperature Sensing, May 2003



- Determine where, within the horizontal leg, the production is coming from (production profile).
- Measure the effectiveness of the fracture stages in the HZ lateral:
 - Is there a correlation between fracture breakdown pressure and production?
 - How do 'failed' fracs contribute to overall production (case 1)?
- Compare conventional memory Production Logging (PL) data with data gathered with DTS on the same well (case 1).

Well Schematic – Case 1



Casing:

219.1 mm,35.72 kg/m,J-55Surface to 606.00 mKB114.3 mm,22.47 kg/m,L-80Surface to 2618.38 mKB114.3 mm,22.47 kg/mP-1102618.38 to 4051.00 mKB

14 Packers Plus Frac Ports located at: 2860.75m, 2959.98m, 3045.11m, 3130.86m, 3229.20m, 3315.29m, 3400.08m, 3497.05m, 3581.11m, 3678.35m, 3764.09m, 3848.50m,3933.05m & 4012.35m (MD)

Coil with PLT logged from 2800.0 to 3974.0 mKB (MD)

Operational Summary – Case 1



Pad Summary

- 4 well pad
- 400m offset on laterals
- Wells were flowed for approximately 2 weeks prior to the logging
- The PLT was run with coiled tubing on all four wells
- DTS survey was performed on only one of the wells

DTS Well Summary

- Days 1 & 2 Production logging run
- Days 3 & 4 Operator produced well
- Day 5 Distributed Temperature Sensing run

DTS Operation Summary – Case 1

- 05:30 06:00 Safety meeting with client and third party crews
- 06:00 08:00 Rig up 9/32 E-line with Pure Energy Dual Fiber Optics
- 10:00 10:20 Conduct 25 MPa Pressure Test
- 11:10 12:45 RIH to Point of Refusal (2753 mKB)
- 12:45 14:31 Tractor @ 12 m/min to 3987 mKB
- 14:55 DTS/DAS survey started
- 15:45 Well opened to flow through 32/64th Bean Choke
- 16:30 Production stabilizes
- 17:33 Well Shut-in
- 23:00 DTS/DAS survey completed. Disconnect fiber optics
- 23:00 01:25 POOH
- 01:45 03:30 Rig out, released from location

22 Hours Total

TRICAN

Well Response Comparison





Well Response During PLT





Horizontal Zonal Contribution Conventional PLT Comparison





Comparison of all PLT Data





Horizontal Zonal Contribution Distributed Temperature





DTS Differential Data





Production Profile Results



Store #	DTS Survey	PL% of	DTS % of			
Slaye #	Rate (m3/d)	Contribution	Contribution			
Frac Port 14	12.8	14.4	8.4			
Frac Port 13	6.6	12.7	4.6			
Frac Port 12	21.8	9	13.7	DTS shows 50% of production from 4 stages.		
Frac Port 11	10.4	11	6.5			
Frac Port 10	10.2	2.9	10.7			
Frac Port 9	2.9	9.3	1.8			
Frac Port 8	19.6	5.3	12.2			
Frac Port 7	10.7	2.2	5.4	PL shows more		
Frac Port 6	5.4	1.5	3.4			
Frac Port 5	10.4	11	6.5	distributed		
Frac Port 4	12.0	9	7.5	profile.		
Frac Port 3	6.0	1.6	3.8	p		
Frac Port 2	20.6	4.8	12.9			
From Below	3.3	5.3	2.6			
T	otal 160.0	100.0	100.0			

PLT data compared to DTS





PLT data compared to DTS







- DTS can be used instead of typical PL tools to determine the production profile of a horizontal well.
- DTS provides information about production behind the casing at the rock face.
- DTS surveys can be performed on wells that do not have permanent fiber installations.
- DTS surveys can be run in under 24 hours.

Well Schematic – Case 2







- Determine where, within the horizontal leg, the production is coming from (production profile).
- Measure the effectiveness of the fracture stages in the HZ lateral.
- Determine what information (GR, Gas Counts, TOC, Tonnage, Rate, etc.) correlated with the best producing stages of a top producing well.
- Determine production profile after ~50% EUR.

DTS Operation Summary – Case 2 ORELIANCE TRICAN

Well Summary - Top producing well in field

Day 1

23:20 RIH with Fiber Optic Coil

36 Hours Total

Day 2

- 03:50 Coil frictions off at 3450.3 mKB, DTS monitoring begins
- 07:00 Open well to flow (8 hour flow monitoring)
- 16:10 Shut-in Well (14 hour shut-in monitoring)

Day 3

06:10 DTS Monitoring is Complete – POOH

12:30 Job Completed

25 Hour DTS Survey

Flow Rate & Pressure during DTS Survey – Case 2





Flow Rate & Pressure during DTS Survey – Case 2





DTS Differential Data





DTS Differential – Stages 4 to 15 CRELIANCE TRICAN



DTS Differential – Stages 16 to 26 CRELIANCE TRICAN



Production Profile Results



Stage #	ŧ	Rate (m3/d)	% of	Stage #	:	Rate (m3/d)	% of Contribution
			Contribution	Frac Port 15		1.4	0.7
Frac Port 26		11.2	5.5	Frac Port 14		8 1	30
Frac Port 25		5.9	2.9	Free Dert 12		4.4	0.7
Frac Port 24		17.1	8.3	Frac Port 13		1.4	0.7
Frac Port 23		19.5	9.5	9 5 Frac Port 12		9.0	4.4
Erao Bort 22		2.4	Frac Port 11		3.8	1.9	
Frac Port 22		3.1	1.5	Frac Port 10		2.3	1.1
Frac Port 21		15.9	7.8	Frac Port 9		52	25
Frac Port 20		5.3	2.6	Free Dert 9		3.2	2.5
Frac Port 19		7.5	3.7	Frac Port 8		3.0	1.5
Frac Port 18		73	36	Frac Port 7		0.12	0.1
Frac Port 17		22.2	10.9	Frac Port 6		1.5	0.7
		22.2	10.0	Frac Port 5		5.2	2.5
Frac Port 16		26.1	12.7	Frac Port 4		0 77	04
	Total	141.1	68.8%	From Bolow		22.2	40.0
				FIOIII DEIUW		LL.L	10.0
					Total	64.0	31.2%

50% of production from 5 stages



- No clear correlation between expected reservoir quality indicators and production results were observed.
- The upper 40% of the HZ was contributing 70% of production despite little expected reservoir heterogeneity or changes to fracture design.
- DTS is cost effective; a typical survey costs about the same as a PL survey.

Other DTS PL Applications HZ Injection





Other DTS PL Applications HZ Oil Production





DTS Applications Summary



- HZ Single Phase Wells
 - Water injectors, gas producers with low GWR
- HZ Oil Wells
 - Requires well to be flowing or be lifted with swabbing/gas lift
 - Works well with high GOR
- Vertical Injection Wells
 - Water, CO2 and Acid Gas Injection
- HZ Injection Well Integrity Logging for Regulatory Approval
- Thermal Well Monitoring

Conclusions



- DTS PL surveys can be conducted on wells without permanent Fiber installations
- DTS surveys can be run in under 24 hours
 - Longer warm back times give more detailed surveys
- DTS is cost effective; a typical survey costs about the same as a PL survey with reduced operational risk
 - Passive sensing
 - No moving parts in the BHA
 - Real time data acquisition
- In many cases, no fluid is pumped into the well bore



- Murphy Oil Company, Canada
 - Lucy Rock
- FMC Wireline
 - Steve Wierenga
 - Robert Hawkes (now at Trican)
- SPE & ICoTA

