ULTRA-LIGHTWEIGHT PROPPANT RESURRECTS ABANDONED DELAWARE PRODUCER

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ABSTRACT

The Delaware sand is a common oil producing formation in the Permian Basin. It is a low permeability sandstone that requires proppant fracture treatments in order to be economically viable. Typically these treatments consist of crosslinked water based fluids with polymer loadings of approximately 30 pounds per one thousand gallons and carry from 25,000 to over 200,000 pounds of 20/40 mesh sand.

This is a case history about one Delaware producer originally completed in November of 1992 with an initial fracture treatment similar in fashion to those described above, re-stimulated in November of 1996, but with a larger quantity of proppant and then subsequently temporarily abandoned in June of 2000. The details of a third propped fracture treatment, using an ultra-lightweight proppant at a fraction of the quantities previously used and the production response that resulted is the basis for this paper.

INTRODUCTION

The Delaware formation in Eddy County, New Mexico is primarily a fine grained, moderately to well sorted quartz and feldspar rich sandstone. The grains are cemented by a combination of clays, compaction and calcite, with the clays and compaction dominating. The quartz content varies from 50% to 60% while the feldspar content is 16% to 21% and clays make up 13% to 17%. Hydrochloric acid soluble material ranges from 4% to 16% and is primarily calcite with slight pyrite content. A more complete mineralogical breakdown is listed in Table 1.[1] The average bottomhole static temperature is approximately 150°F in this area. The formation typically has a fracture gradient of 0.49 psi/ft. The average porosity and gas permeability are 11.8% and 0.58 mD respectively, Table 2.[1] The target production intervals are 7500 to 8000 feet. Table 3 lists some of the rock mechanical properties that have been determined from core samples.[2]

Fracture stimulation has been the method of achieving economic production for many years. Several papers have been written exploring the modeling of propped fracture treatments in the Brushy Canyon.[3] In addition, evaluation of fracture heights through the use of radioactive isotope tracers has been used in the attempt to optimize designs.[4] In all of these cases the push for several pounds per square foot of created fracture area was the goal. The advent of new materials has made a significant change the current approach.

Figure 1[5], illustrates the conductivity of 20/40 sand at various pounds per square foot and how at 0.078 pounds per square foot (partial monolayer) conductivity is 2900 md-ft at 5000 psi closure and at 5 pounds per square foot the conductivity is 3000 md-ft. Both of these over the years have been difficult to achieve. Because of settling and the difficulty of getting enough fracture width to carry 5 pounds per square foot throughout the fracture, the partial monolayer was impractical. Therefore the industry has settled for getting close to 2 pounds per square foot which at 5000 psi closure gives 1700 md-ft conductivity. This is more than one half of the conductivity given in both the previously outlined scenarios. Throughout the last few years fracture stimulation of low permeability reservoirs with ultra-lightweight proppants to achieve a partial monolayer effect has become more feasible. This is due in part to ultra-lightweight proppants having a similar specific gravity to that of their carrying fluid; specific gravity 1.25. Because of the similar specific gravities between the ultra-lightweight proppant and its carrying fluid, proppant settling effects are much less of a problem than those seen with sand; specific gravity 2.65.

CASE STUDY

The well was drilled to 15,100 feet and temporarily abandoned in February of 1974 as shown in the wellbore diagram, Figure 3. In November of 1992 it was re-completed in the Delaware LBC (7583' to 7593') with 4 spft 41 holes total. The interval was fracture stimulated with 6000 gallons of a 30 pound borate crosslinked fluid carrying 26,000 pounds of 20/40 Ottawa sand. The well produced 271 BO and 1505 BW through November 1996. It was fracture stimulated again in November of 1996 with 38,000 gallons of 30 pound borate crosslinked fluid carrying

202,000 pounds of 20/40 Brady sand. Through June 2000 586 BO and 2967 BW was produced. The well was again temporarily abandoned.

The well was re-completed again in July of 2007 in the Delaware LBC with perforations at 7498' to 7508' and 7559' to 7569'; 20 holes total. These intervals were fracture stimulated with 145,817 gallons of slick produced water and 10,553 pounds of an ultra-lightweight proppant as per the pump schedule outlined in Table 4. The rate and pressure chart is in Figure 3. To date the well has a cumulative production of 2.1 MBO, 4.1 MMCF, and 9.9 MBW from the most recently added Delaware LBC zones. The average production rates have been 33 BOPD, 65 MCFD and 158 BWPD. Production history is illustrated in Figure 4. It can be seen that the current production is in the 800 BOPM range while previously from 1992 to 2000 monthly averages were around 180 BO.

CONCLUSIONS

1.) Sustained production from the Brushy Canyon is achieved through the propping of a created hydraulic fracture using an ultra-lightweight proppant to create a highly conductive partial monolayer.
2.) Multiple re-fracturing treatments can be feasible.

REFERENCES

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2.) BJ Services Internal Report: "Petrologic Analysis of Samples 93110510," January 1993, by DeVine, C. S.
3.) Johnson, R. L.: "The Application of Hydraulic Fracturing Models to Characterize Fracture Treatments in the Brushy Canyon Formation, Delaware Group, Eddy County, New Mexico," paper SPE 35195 presented at the SPE Permian Basin Oil and Gas Recovery Conference, Midland, Mar 27-29, 1996.
4.) Johnson, R.L. and Woodroof, R.A.: "The Application of Hydraulic Fracturing Models in Conjunction with Tracer Surveys to Characterize and Optimize Fracture Treatments in the Brushy Canyon Formation, Southeastern New Mexico," paper SPE 36470 presented at the SPE Annual Technical Conference and Exhibition, Denver, Oct. 6-9, 1996.
5.) *The Fracbook*, Halliburton Services, Duncan, Ok (1971) 92.

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Table 1 Typical Delaware Mineralogical Composition				
Minerals	Composition, %			
	Depth, feet			
	7870	7893	7964	7969
Quartz (SiO_2)	52	59	60	55
Plagioclase Feldspar	12	12	14	15
Potassium Feldspar	4	5	4	6
Calcite	16	10	3	9
Siderite	---	---	---	1
Pyrite	trace	trace	1	trace
Chlorite	4	4	4	3
Mixed-Layer Illite/Smectite	11	9	13	10
Totals	100	100	100	100

Table 2 Typical Reservoir Parameters for Delaware		
Depth, feet	Gas Permeability, mD	Porosity, %
7870	0.42	9
7893	1.24	12.4
7964	0.37	14.9
7969	0.28	10.9

Table 3 Typical Rock Mechanical Properties of Delaware From Core Samples		
Depth, ft	Young's Modulus	Poisson's Ratio
7821	2.93E06	0.24
7838	2.54E06	0.26
7865	1.27E06	0.30

Table 4 Treatment Schedule		
Fluid Description	Proppant Concentration, ppa	Fluid Volumes, gals
7-1/2% Hydrochloric Acid	Acid	1000
Slick Produced Water	Pad	18270
Slick Produced Water	0.05	20000
Slick Produced Water	0.10	60500
Slick Produced Water	0.20	7500
Slick Produced Water	0.30	5000
Slick Produced Water	Flush	4830

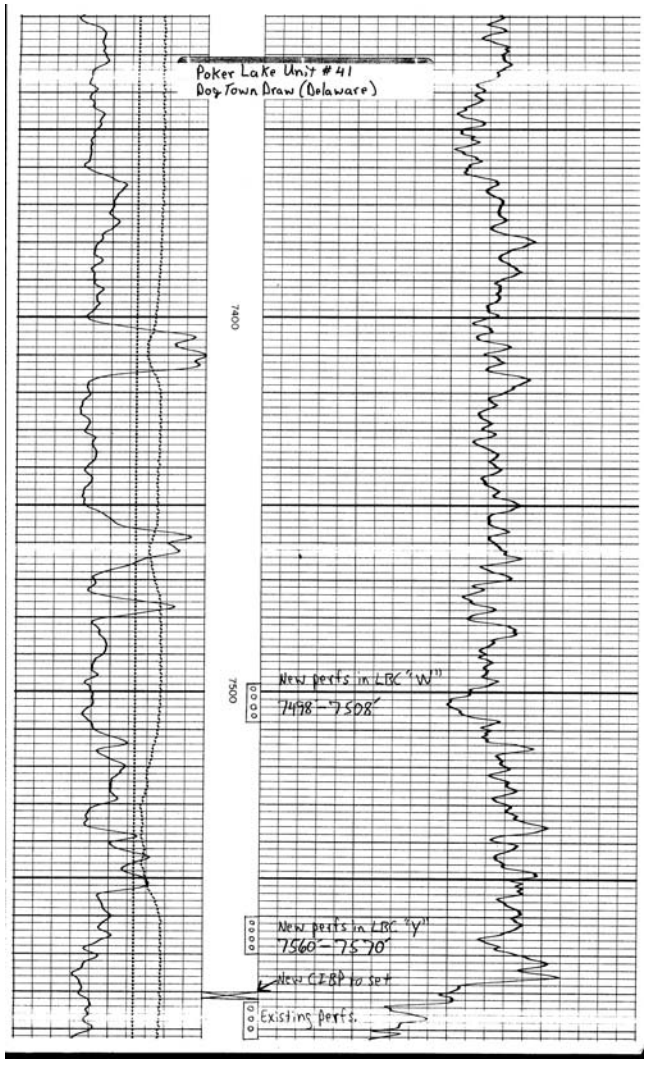


Figure 1 – Log Section Across Delaware Interval

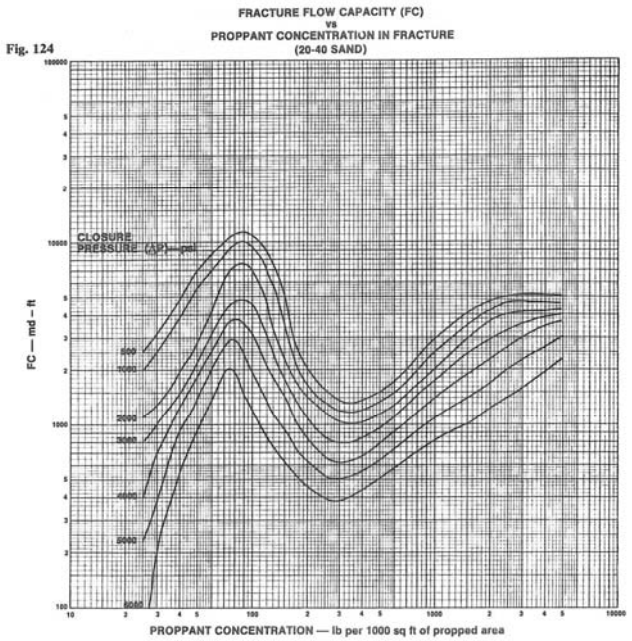


Figure 2 – 20/40 Sand Conductivity as Function of Pounds Per 1000 Square Feet

LEASE: POKER LAKE UNIT **WELL #:** 41
FIELD: DOG TOWN DRAW (DELAWARE)
LOCATION: 1980' FNL & 1980' FEL, SECTION 21, T24S, R30E
COUNTY: EDDY **ST:** NM **API#** 30-015-20933

X:
Y:
Lat:
Long:

KB: 3391
GL: 3360
SPUD DATE: 9/30/1973
COMP DATE: 2/19/1974

SURFACE CASING

SIZE:	20"	
WT/GRD:	94#	H40
SET @:	516'	
SX CMT:	980	LITE
SX CMT:	200	C
CIRC:	Y	
TOC:	SURF	100 SX
HOLE SIZE:	26"	0-563'

INTERMEDIATE CASING

SIZE:	13-3/8"	
WT/GRD:	68#	K55
WT/GRD:	54.5#	K55
WT/GRD:	48#	H-40
SET @:	3868'	
SX CMT:	4025	LITE
SX CMT:	300	C
CIRC:	Y	100
TOC:	SURF	DVT 1711'
HOLE SIZE:	17-1/2"	563-3868'

PRODUCTION CASING

SIZE:	9-5/8"	
WT/GRD:	43.5#/40#	N-80
WT/GRD:	43.5#	JL 95
WT/GRD:	40#/43.5#	N-80/JL 95
SET @:	11342'	
SX CMT:	3490	LITE
SX CMT:	1940	H
CIRC:	Y	DVT 3814'
TOC:	SURF	DVT 6542'
HOLE SIZE:	12-1/4"	3868-11338'

PRODUCTION LINER #1

SIZE:	7-5/8"	
WT/GRD:	39#	S95 XLINE
SET @:	11073-14270'	
SX CMT:	450	H
CIRC:	Y	11,073'
TOC:	11073'	
HOLE SIZE:	8-1/2"	11338-14270'

PRODUCTION LINER #1

SIZE:	5"	
WT/GRD:	18#	N-80 XLINE
SET @:	14061-14740'	
SX CMT:	145	H
CIRC:	Y	
TOC:	14061'	
HOLE SIZE:	6-1/2"	14270-14740'

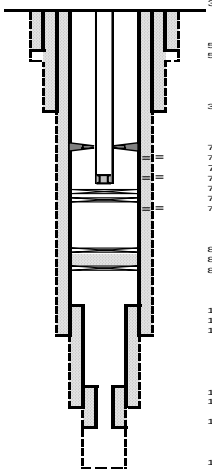
PRODUCTION TBG

SIZE:	2-7/8"	
WT/GRD:	6.5#	J-55
TAC @:	7272'	
SN @:	7521'	

PERFORATION DATA

7/31/07 LBC "Y" 7,559 to 7,569'
Loaded tbg w/ 180 bbls KCl wtr + 43 bbls 2% KCl. Spot 500 gals 7-1/2% NEFE HCl acid. Breakdown w/ 2800 psi . Pmp acid @ 5 bpm & 2400 psi. Overdisplaced w/ 2 bbls 2% KCl.

LBC"W" 7,498' to 7,508 (10 holes).
Break circ & spot 500 gls 7-1/2% NEFE HCl acid to 1 bbl short EOT. Breakdown w/3100 psi. Pmp acid away @ 8 bpm 2500 psi. Overdisplaced w/ 2 bbls 2% KCl.



31' **GL**		
0' **KB**		
516'	20" 94# H40 CSG	
563'	26" HOLE	
3868'	13-3/8" 68/54.5/48# K55/H40 CSG	
	17-1/2" HOLE	
7272'	TAC	
7498-7508'	**Perfs (10 holes 7/31/2007)**	
7560'	EOT 7521' SN	
7559-69'	**Perfs (10 holes 7/31/2007)**	
7578.5	CIBP	
7580.5	CIBP	
7,583-93'	Perfs (4 jspf 41 holes 11/9/1982)	
8149'	CIBP	
8159'	35' CMT CAP	
8179'	**CIBP** [ORGINALLY SAID SET @ 7915' W/ 35' CMT CAP]	
11073'	TOP 7-5/8" LINER	
11342'	9-5/8" 43.5#/40# N80/JL95 CSG	
11342'	12-1/4" HOLE	
14061'	TOP 5" LINER	
14270'	BTM 7-5/8" 39# S95 LINER	
14740'	BTM 5" 18# N80 LINER	
15,100'	6-1/2" HOLE	

PBTD: 7578'
TD: 15100'

TOPS	*NEED TO VERIFY W/ LOG*
470	*RUSTLER*
800	*SALT*
3576	*B SALT*
3840	*DELAWARE LIME*
3878	*DELAWARE SAND*
7685	*BONE SPRING*
8620	*1ST BONE SPRING*
9260	*2ND BONE SPRING*
10560	*3RD BONE SPRING*
10944	*WOLFCAMP*
13080	*STRAWN*
13258	*ATOKA*
13492	*ATOKA REEF*
13950	*MORROW*
14267	*BASE LIME*
14355	*ZONE 3*
14505	*ZONE 4*
14615	*ZONE 5*
14780	*ZONE 6*
14930	*T LOWER MORROW*
15310	*T BARNETT*
15600	*T MISS LIME*
16165	*T DEVONIAN*

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Figure 3 – Wellbore Diagram

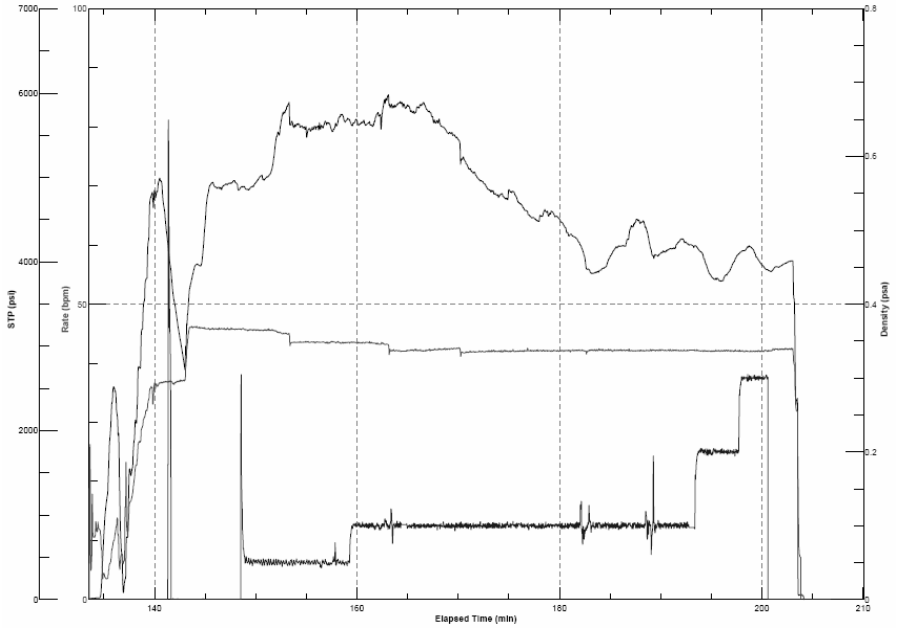

Figure 4 – Treatment Rate and Pressure Chart

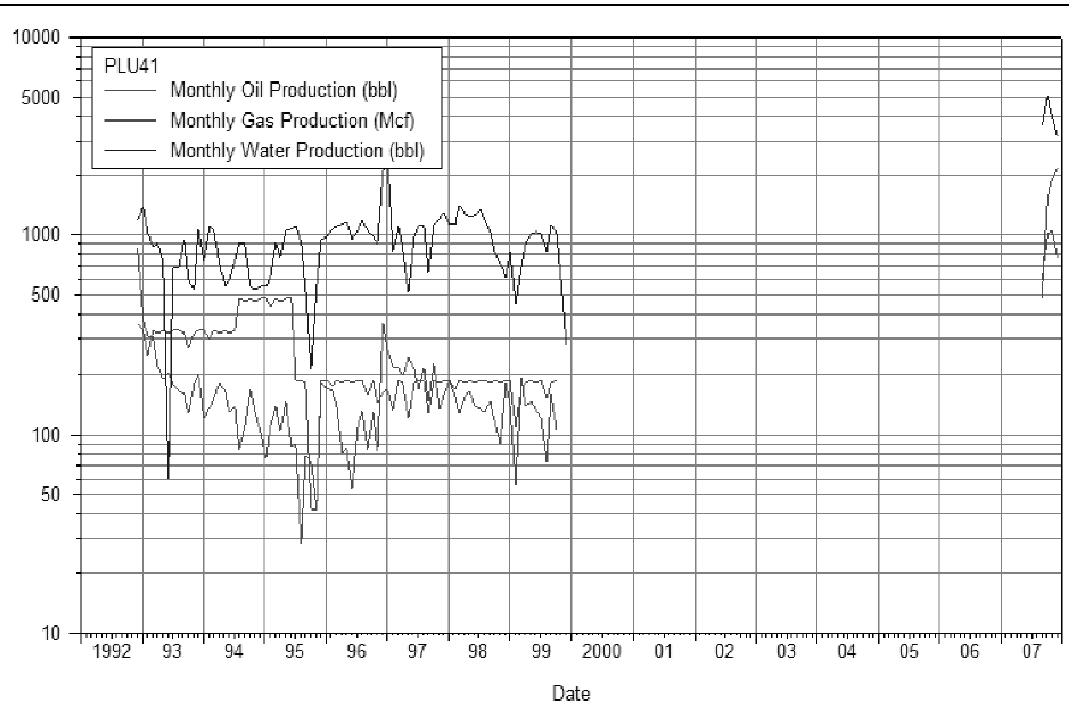

Figure 5 – Production History