Searching for the “Magic Bullet” the Ideal Completion of the North Dakota Bakken

Walt Kordziel

Schlumberger Oilfield Services

ND Bakken Completion Considerations

Minot, North Dakota

May 9, 2006

Schlumberger

North Dakota Activity Overview

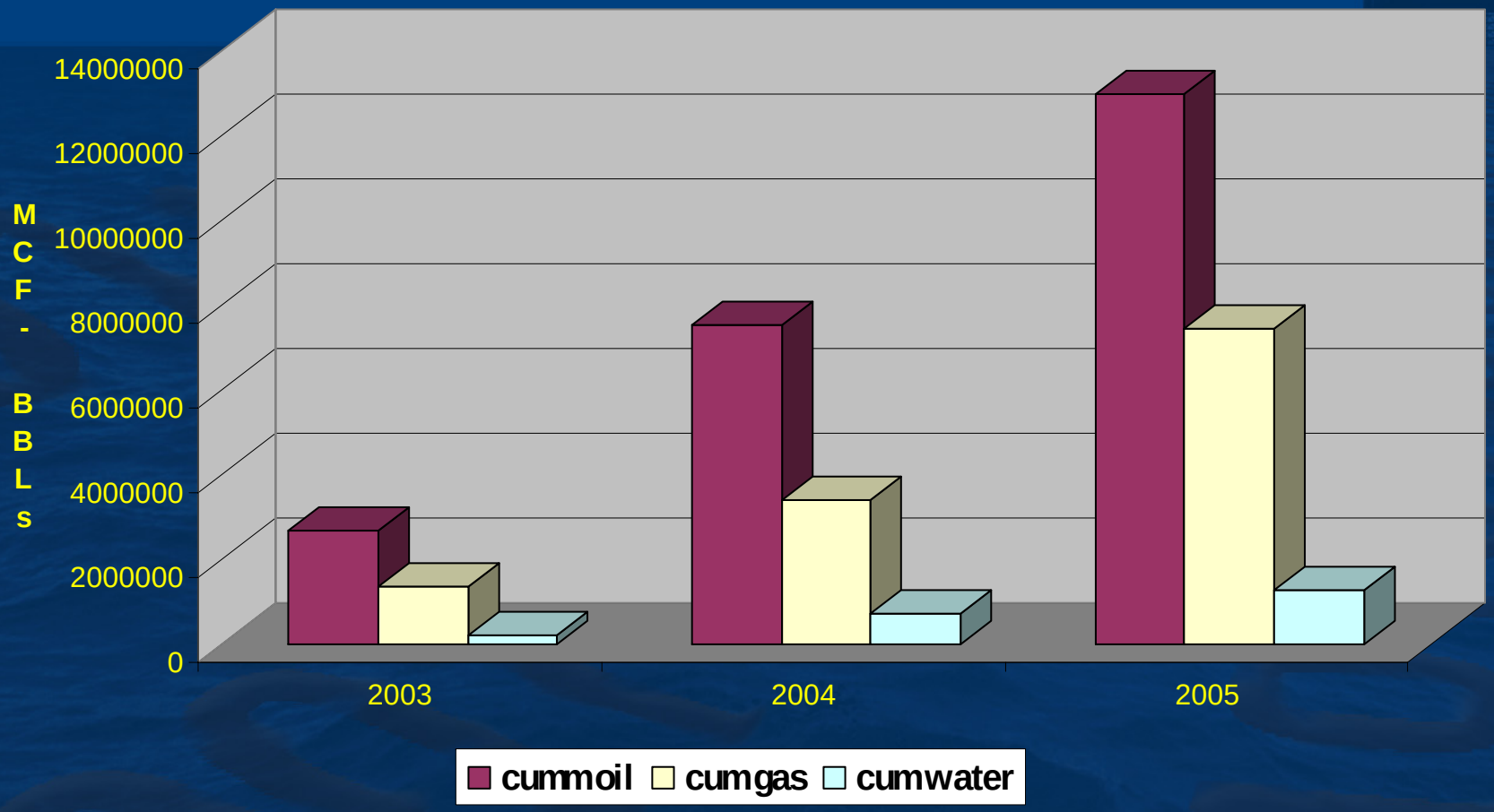
- About 150 Wells has been drilled to date in Mid Bakken in North Dakota
- 40 wells have are out of tight hole status

and production data available.

- A hand full of wells are producing at economic rates compared to Richland Cty Mt.
- Majority of activity shifting from Montana to North Dakota. Millions of acres under lease.

Schlumberger

MT Mid Bakken Production



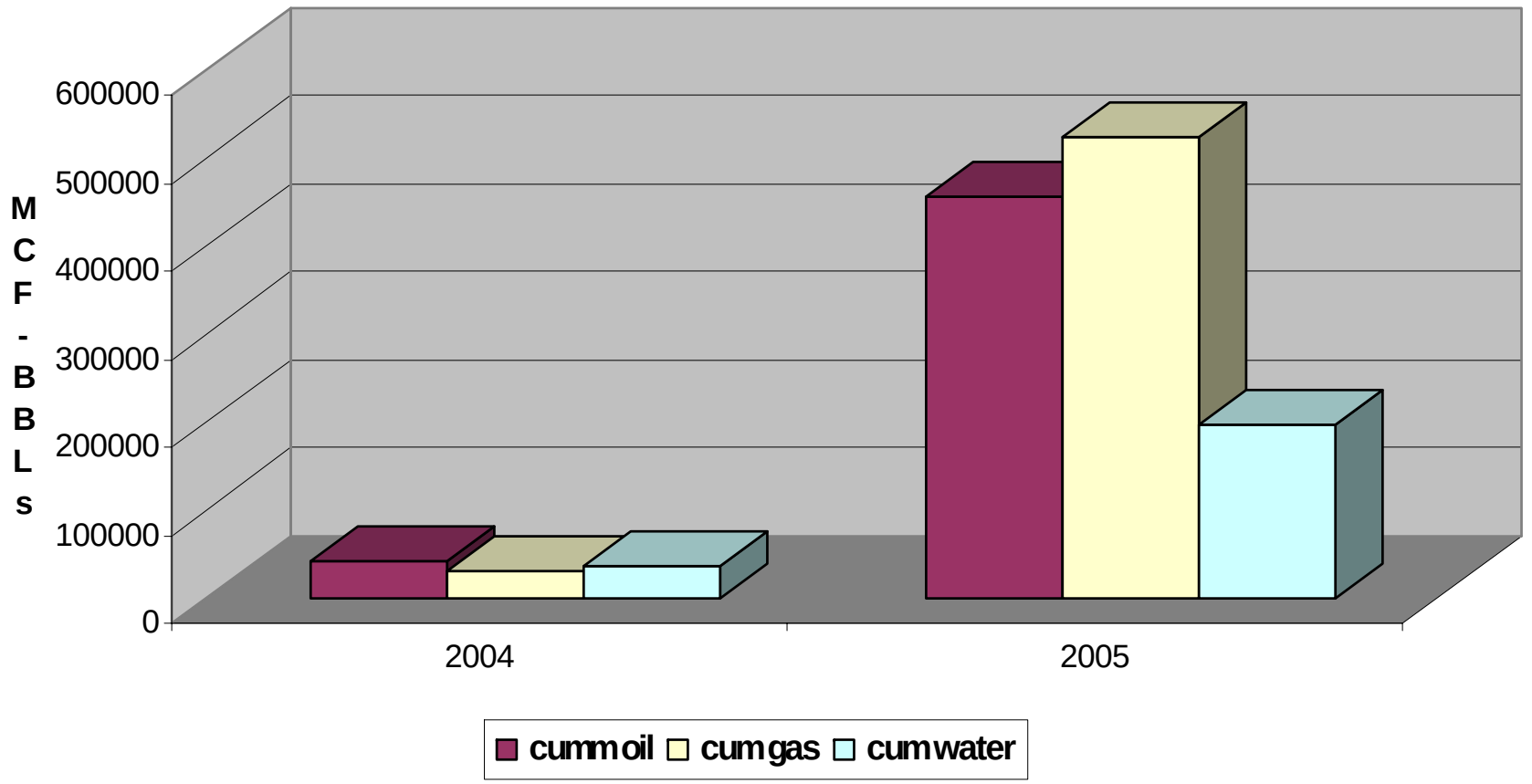
Schlumberger

Montana Average BOPD Production

API	OPERATOR	WELL NAME	T-R-S	FIELD-NAME	BBLS-OIL-PROD	MCF-GAS-PROD	BBLS-WATER-PROD	DAYS	ABOPD
083-22255	Continental	Hanna 2-31H	25N-53E-31 NE NE	Elm Coulee	148535	81248	4153	113	1314.5
083-22238	Burlington	BR 24-29H	25N-53E-29 SE SW	Elm Coulee	177601	61922	4375	318	558.5
083-22297	EOG	Vairstep 2-22H	25N-53E-22 NW NE	Elm Coulee	38032	21857	2130	71	535.7
083-22185	Burlington	State Blackjack 41-36H	25N-52E-36 NW NE	Elm Coulee	148667	34144	6519	273	544.6
083-22078	Burlington	BR 32-4H 43	24N-53E-9 NW NE	Elm Coulee	80862	17928	4715	123	657.4
083-22224	Slawson	Matador 2-13H	24N-53E-13 SE SW	Elm Coulee	165027	84843	3851	299	551.9
083-22079	Burlington	BR 31-2H 43	24N-53E-11 SE SW	Elm Coulee	138366	35596	5437	196	705.9
083-22216	Continental	Thomas 1-22H	23N-56E-22 SW SW	Elm Coulee	14570	5683	4007	28	520.4
083-22355	Lyco	Frostbite-Harold 7-4H	23-57E-7 NW NW	Elm Coulee	1714	26	200	2	857.0
083-22333	Lyco	Bullwinkle-Able 3-2H	23-57E-3 NW NE	Elm Coulee	5498	115	387	9	610.9

Schlumberger

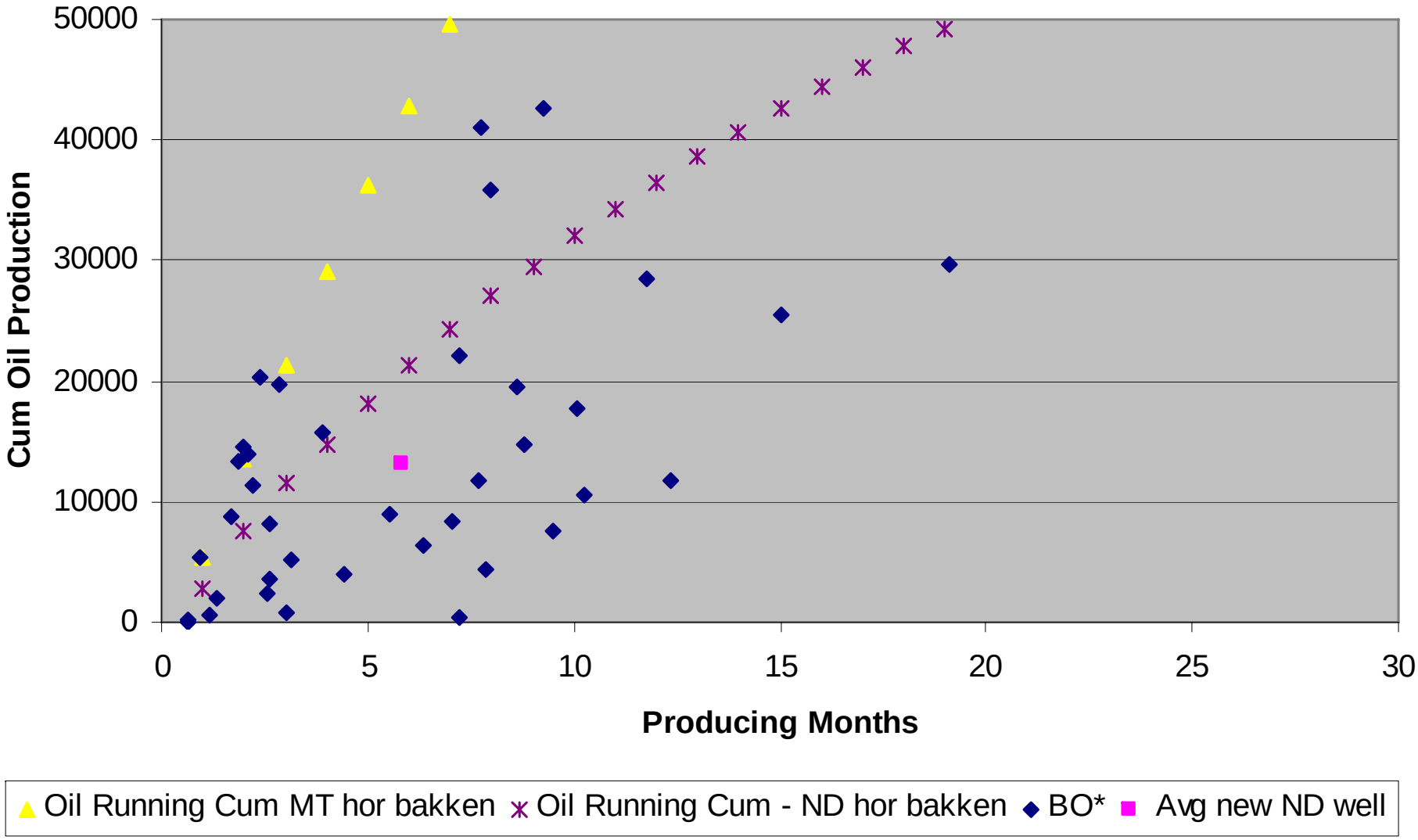
ND Mid Bakken Production



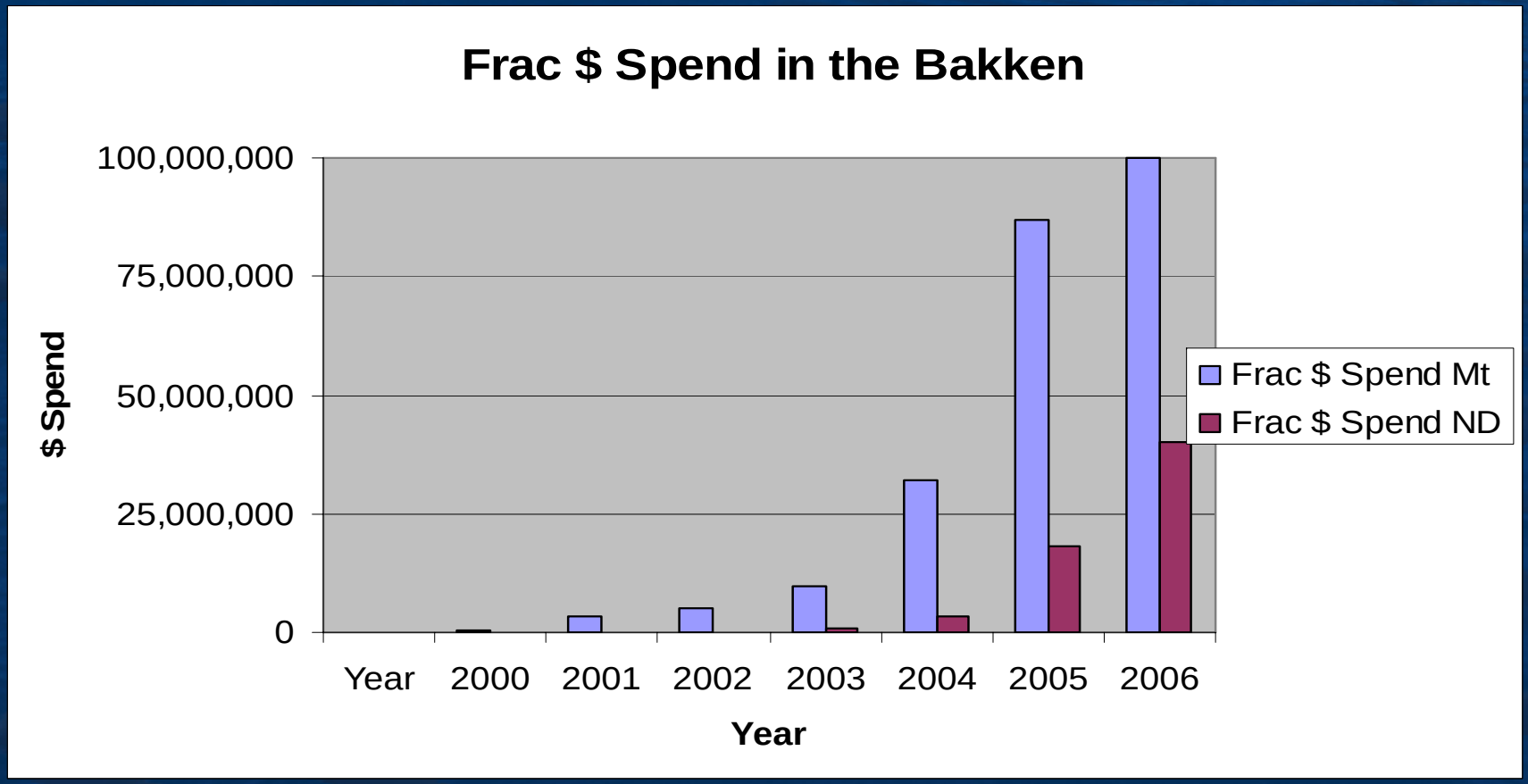
Best IP North Dakota

OPER	NAME	FIELD	T-R-S	CO	IP Oil	Lateral 1 End	MD-1	TVD-1	Lateral 2 End	MD-2	TVD-2
Headington	State Logosz 44X-16	St. Demetrius	142-99-16 SESE	Billings	505	142-99-16 N	16550	10985			
Murex	Angela Kaye 2-11H	West Bank	156-96-2 SESE	Williams	484						
Murex	Stacey-Lynne 1-12H	West Bank	156-96-1 SESW	Williams	463	156-96-1 NE	13921	9734	156-96-12 SESW	14665	9857
Amerada	State 36-31H	Beaver Lodge	156-96-36 NWNE	Williams	401	156-96-36 SE	13261	9771			
Amerada	Russell E Smith 24-4	Capa	155-96-24 SWSE	Williams	395	155-96-25 SE	14402	9751	155-96-24 SENE	12139	9725
Headington	Paluck 41X-28	St. Demetrius	142-99-28 NENE	Billings	376	142-99-28 SW	16879	10860	142-99-21 NWNW	17581	10928
PDC	Fedora 34-22H	Wildcat	146-94-22 SWSE	Dunn	368	146-94-15 SW	18315	10781			
Ansbro	Miller 44-31H	Willmen	143-97-31 SESE	Dunn	334	142-97-31 N	16101	10780			
Nance	Federal 3-28H-R	MonDak	148-104-28 NENW	McKenzie	263	148-104-28 S	14345	10603			
JMG	Burau 4-22H	Larson	162-94-22 NWNW	Burke	260	162-94-27 N	9231	7987			
JMG	Rindel 3-9H-D	Juno	162-96-9 NENW	Divide	250	162-96-9 SE	9054	7925			
Headington	Hove 11X-35	Alkali Creek	155-95-35 NWNW	Williams	250	155-95-35 SE	11640	10145			
Amerada	J. S. Rice 1H-R	Blue Buttes	150-95-7 NENW	McKenzie	238	150-95-7 NE	10964	10679			
BTA Oil	20411 JV-P Melgaard	Stoneview	160-95-2 NWNW	Divide	190	160-95-11 SE	16525	8887			

Schlumberger


Williston Basin - MT v ND Hor Wells
Cum Oil Production
50000
40000
30000
20000
10000
0
0
5
10
15
20
25
30
Producing Months
Oil Running Cum MT hor bakken
Oil Running Cum - ND hor bakken
BO*
Avg new ND well

Evolution of Bakken Frac Activity from Montana to North Dakota



Schlumberger

Differences Between the Bakken in Montana and Bakken in North Dakota.

Montana

- Small contained geographic area 300 + wells, ave prod +230 BOPD at 180 days. Middle Bakken Carbonate
- Varying amounts of technical data has been collected, ie logs, cores, tracers, PL's, frac azimuth.
- Many types of frac designs, lateral lengths, multi laterals, very successful results, majority of prop has been sand.
- Fracs are contained, stress in Middle Bakken is significantly less than bounding layers.
- High consistent Oil Sat and H.
- Good matrix porosity and perm.
- Few tectonic fractures.

North Dakota

- Large spread out geographic area +/- 70 wells at 180 day production, ave + 65 BOPD. Middle Bakken Clastic 10 MM + acres leased
- Very little technical data has been collected, ie logs, cores, tracers, PL's frac azimuth.
- Many types of frac designs, lateral lengths, few multi laterals, variable success, most prop has been ceramics.
- Fracs are not all contained, stress of all layers is variable from area to area, mostly higher.
- Variable Oil Sat and H.
- Variable porosity and little matrix perm.
- Several of the higher rate wells have had significant tectonic fracture contribution.

Variations of Different Bakken Stimulations

Oper	Frac Type/gel	Liner/perf Strategy	Divert	Flush Frac to?	Clean Out Post Frac	When to Run Tub	Prop type etc
A	18-25 lb Xlink Borate gel, linear, fib 70 BPM	5" liner, .5" holes, 1 hole/2-4'	Fibers, 100 mesh, hi gel loads	½ - 2/3 lateral	Yes +/- 1 yr after frac as dic	Prior to flowback	30/50, 20/40 sand 90lb/ft
B	20-25 lb xlink borate, fib 70 BPM	5", 6 - .5" holes at 90 deg/4th jt	Prop slugs and fibers	1/3 of lateral	Only if poor results	Prior to flowback	20/40 ceramic 100lb/ft
C	35 lb xlink to 25lb xlink borate + fiber 70 BPM	4.5 lin, .5 " 6spf, 60 deg/5th jt	Use 6 ppa slugs	No Overflush	Yes after frac	Prior to flowback	20/40 ceramic 90 –100 lb/ft
D	30-35lb Zirc Xlink 70 BPM	4.5 " lin3, .5 " 90 deg phaseholes every 250'	Ball Sealers	Ramp down flush 2/3	No	Flowback up casing until it dies	20/40 sand 85-110 lb/ft
E	30-35lb Zirc Xlink and borate 50 BPM	4.5", 5 - .5" holes at 90 deg/4th jt	Prop slug and sand wedge	Ramp down no overflush	Flowback up casing then clnout then tub	Once well dies up casing and after cleanout	20/40 ceram 100-125 lb/ft
F	20-35 lb xlink borate some 90-120 BPM	Open hole	none	No overflush	No	Flow up casing until well dies then run	20/40 sand 100 lb/ft
G	35 lb xlink to 25lb xlink borate 70 BPM	Open Hole	10-16 lb slugs	1/3 of lateral	No	Flow up casing until well dies then run	20/40 sand 100 lb/ft

North Dakota Technical Questions

- Lithology… Understanding How Formation Changes throughout the Basin
- Lateral Placement… Which Direction is Best
- Natural Fracture Networks… Identifying and Effects on Stimulation and Production
- Hydraulic Fracture Geometry & Placement… How Many and Orientation to Wellbore
- Stimulation Techniques… Type Prop Fracs vs Type Fluid vs liners with limited entry vs isolation packers ??
- Frac Diversion materials or type of tools
- Total Lateral Length, Multi Laterals, Dual, Tri " Satistical Opportunity"
- Matrix contribution

Schlumberger

North Dakota Shale and Clastics dominated with Micro Fractures

From Pitman et al., 2001

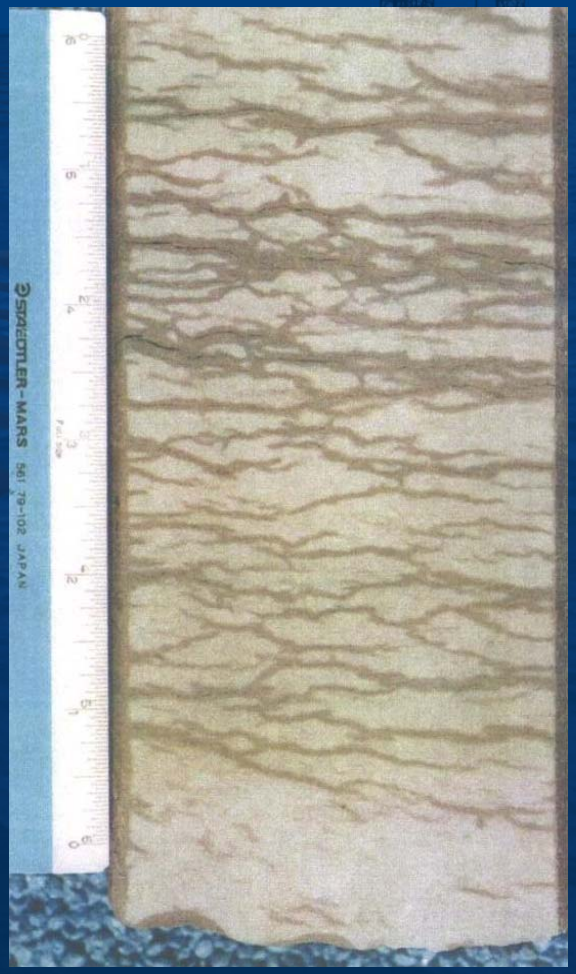
Majority open fractures sub-parallel to bedding

- Form dense network
- Micro fractures throughout the shale, upper and lower members

Formed by oil generation

Direct relationship between thermal maturity and number of fractures in adjacent sandstones and shales

- More mature, more fractures

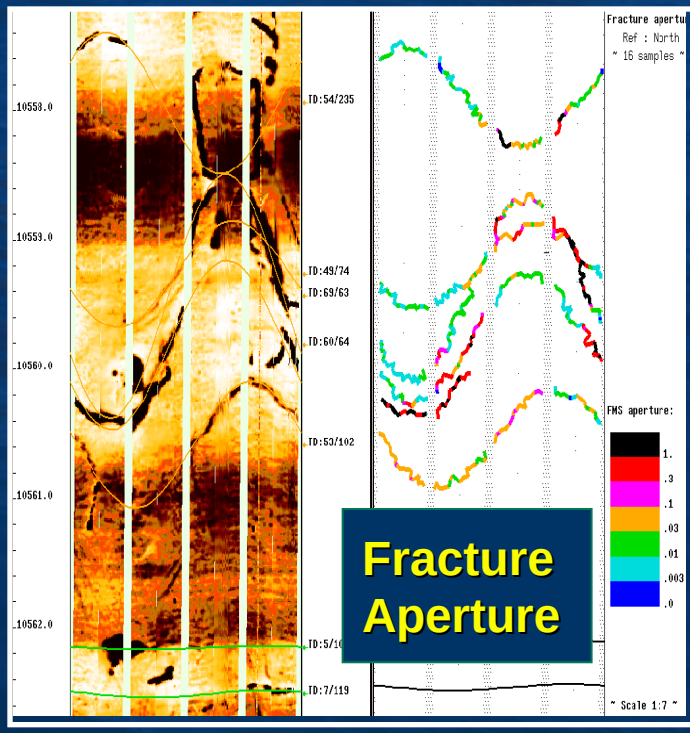


Schlumberger

Natural Fracture Characterization for Completion Optimization

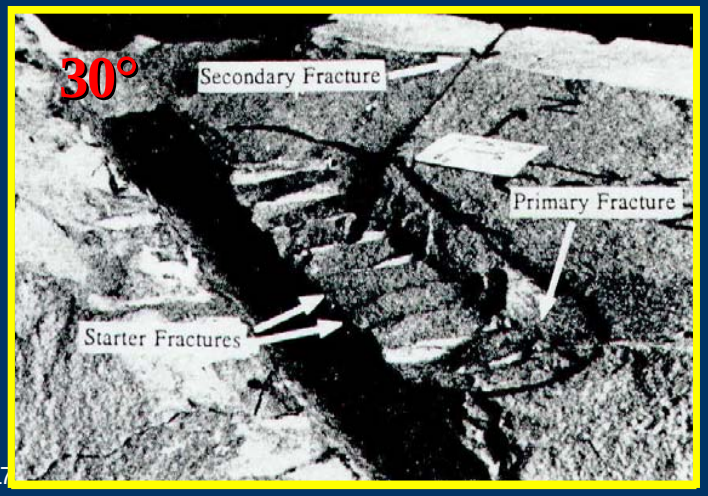
Characterize the Tectonic Natural Fracture parameters through Logs/Cores (aperture, porosity, dilation pressure)

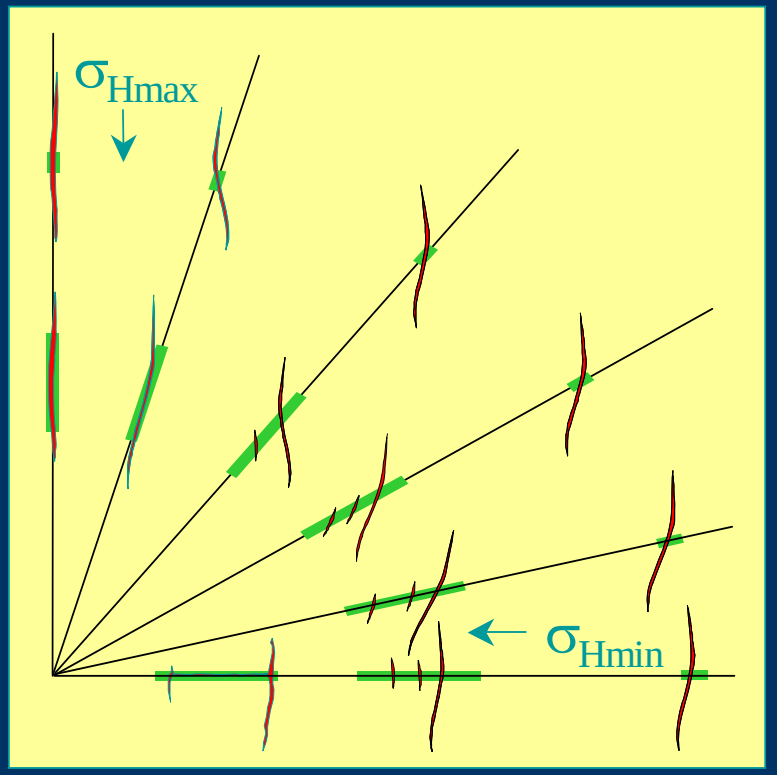
Apply this information to formulate the optimum additive combination and fluid type, to minimize completion fluid damage



Schlumberger

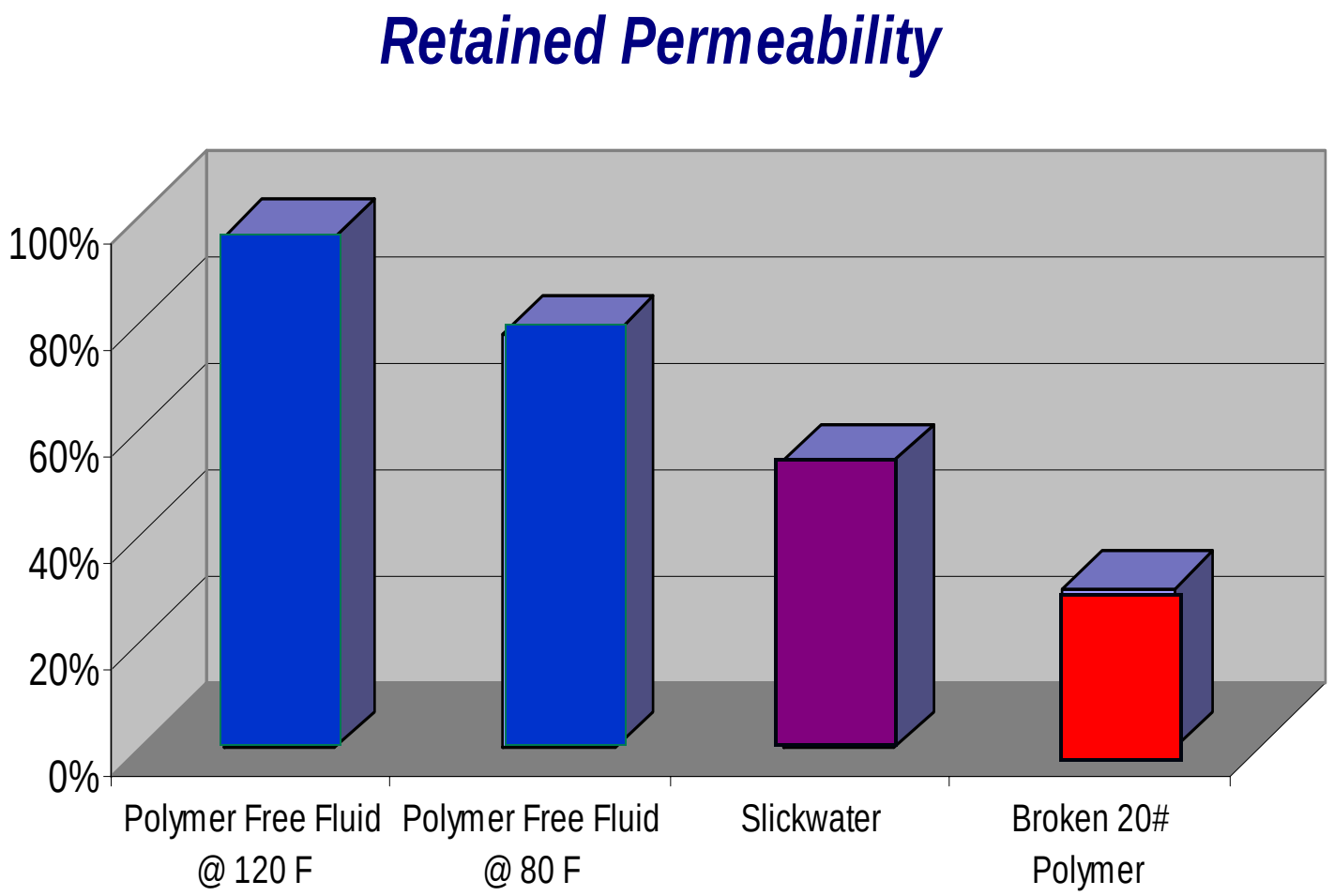
Effect of Wellbore Azimuth





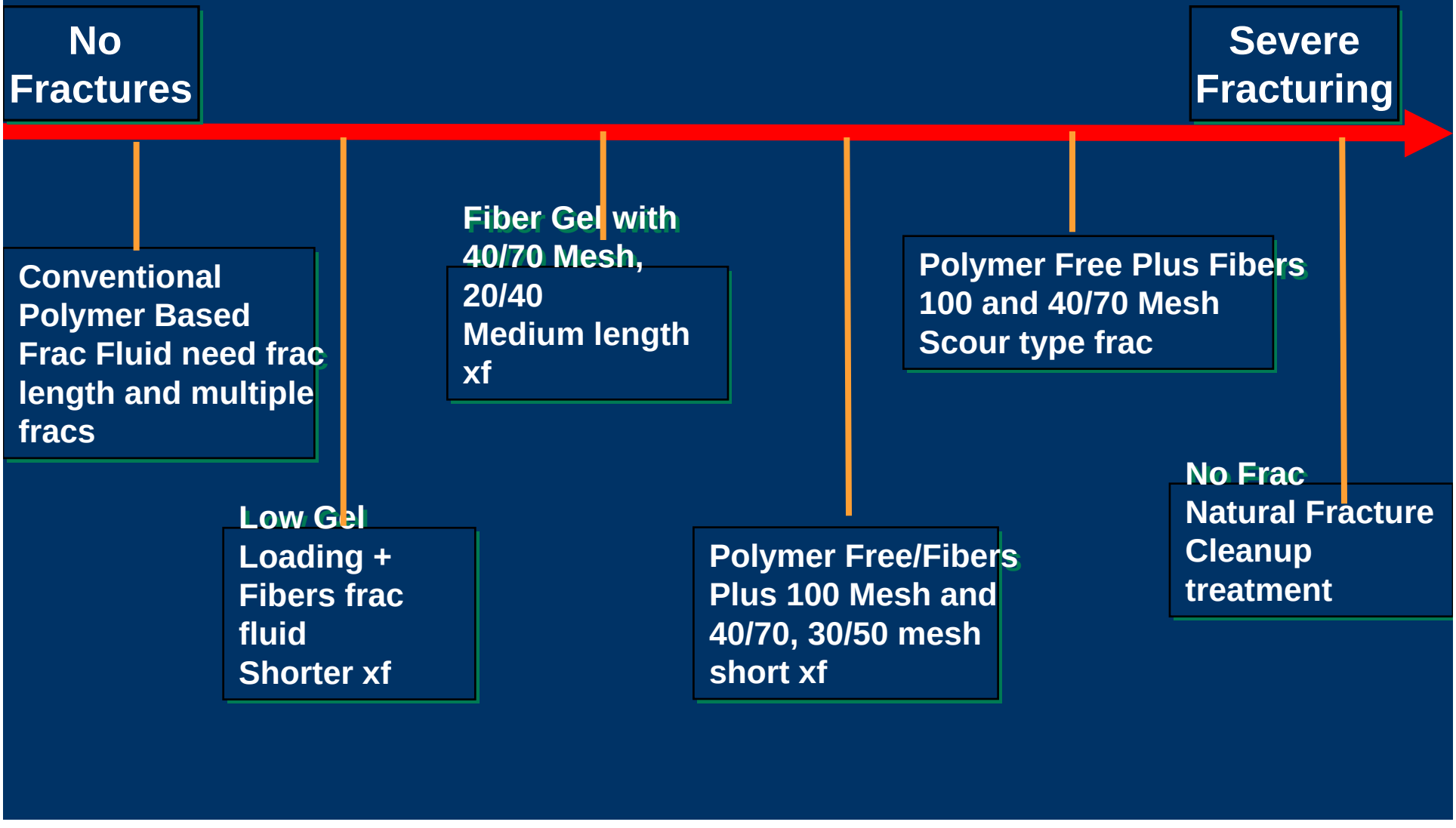
Schlumberger

Natural Fracture Damage from Fracturing Fluid



Schlumberger

Natural Fracture Severity Decision line
(GeoSolution)



Recommended Direction for Fluid Selection in ND Bakken wells

- Proppant suspension properties and effective fluid breaks adequate to prevent settling in horizontal section, minimize cleanouts, ie fibers
- High near-wellbore conductivity to minimize affects of flow convergence at the wellbore, higher strength prop if frac is transverse, maybe a combination of both.
- Control of fluid loss through natural fractures, fibers.
- Clean fluids to minimize natural fracture damage ie drop gel loading or go to visco elastic non gelled systems

Further Data Challenges Needed to Achieve Optimum Completions in North Dakota

- More Imaging or sonic data to Identify type of fractures.
- Determine major max and min stress directions over larger geographic area.
- Determine stress contrast of bounding layers.
- Production log data, how long horizontal laterals produce.
- Micro Siesmic to determine number of and orientation of fracs.
- Mechanical Open hole isolation tools to achieve long transverse fractures.

Drawbacks and Challenges to Developing ND Bakken

- Increased service costs drilling, pipe, frac, completion etc
- Lower production results compared to MT.
- Rig availability
- What data to acquire.
- Cost to benefits of collecting data and applying in a value added manner.
- Cost to benefits of new cleaner fluid technologies
- Lease expiration clock.

Summary: Horizontal Well in Bakken Shale Formation

- Will be hits and misses, productive areas will be narrowed down.
- New technologies to evaluate are available and will be applied.
- Service availability is catching up to demand.
- Combinations of evaluation tools combined with evolving fracturing fluids and techniques should drive higher productivity.
- We should find the “Magic Bullet” combination to make consistent successful North Dakota Bakken completions.