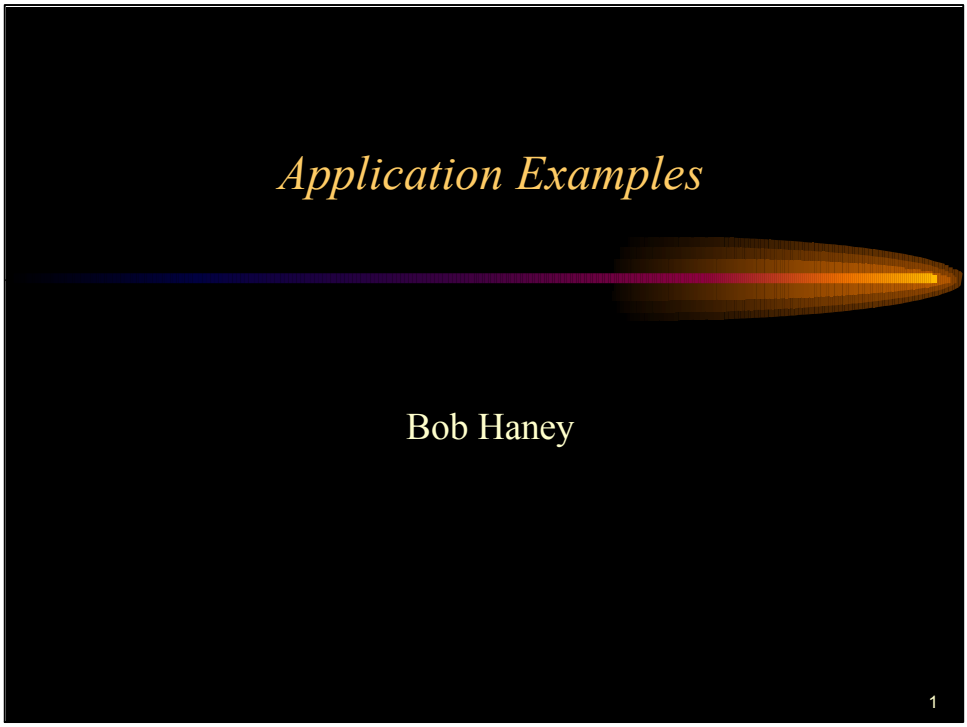
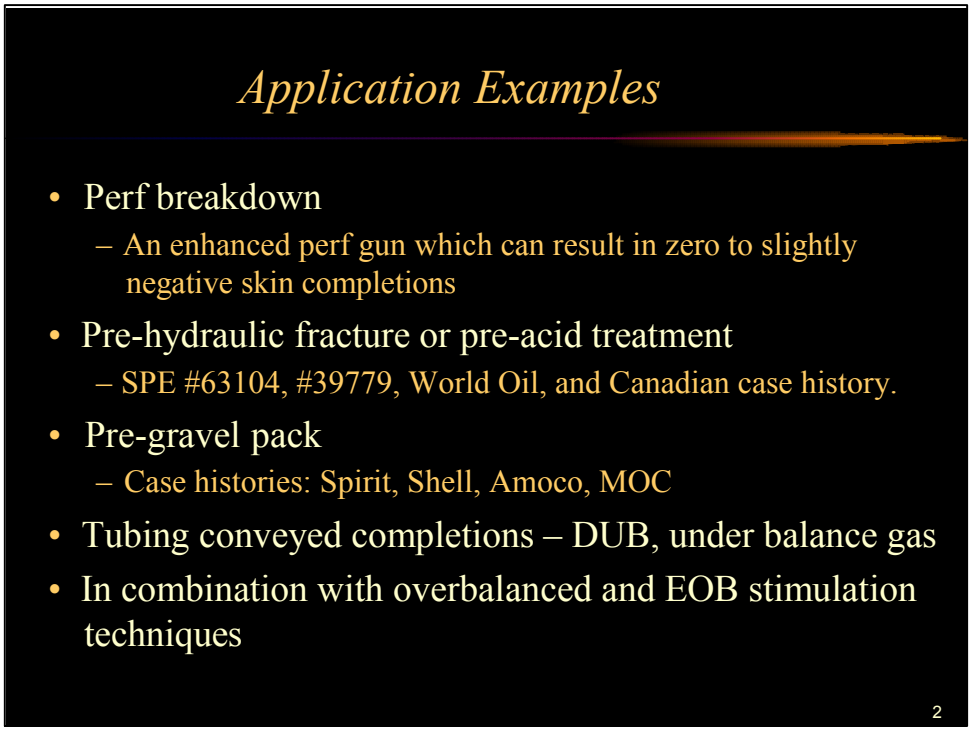


Propellant use goes back >40 years and had a spotty history in the early years, including a lack of positive well response and/or equipment damage.

The extensive use of high speed data recorders and computer modeling has greatly improved the understanding of downhole dynamics and led to much better job design, minimizing the chance of problems and optimizing production.

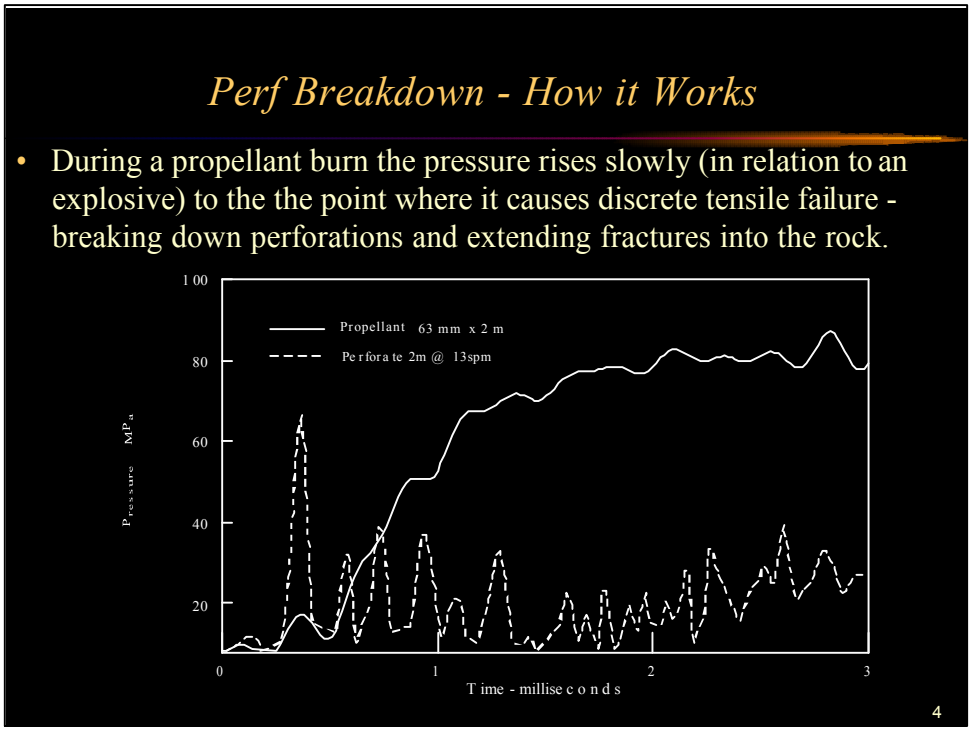


Propellant stimulation produces a high pressure pulse which breakdowns perforations resulting in decreased flow resistance to or from the formation. This will help almost every well where it can be properly used .

Application examples. -- cont.

- Injectors
- Treating zones with near gas / oil / water contacts.
- Stripper wells and low pressure formations
- Shallow Heavy Oil
  - SPE # 37531, Indonesia, California
- Horizontal wells
  - primary and pre frac stimulation
- Naturally fractured formations
- Use in combination with Polymer technologies
  - SPE 38789

3

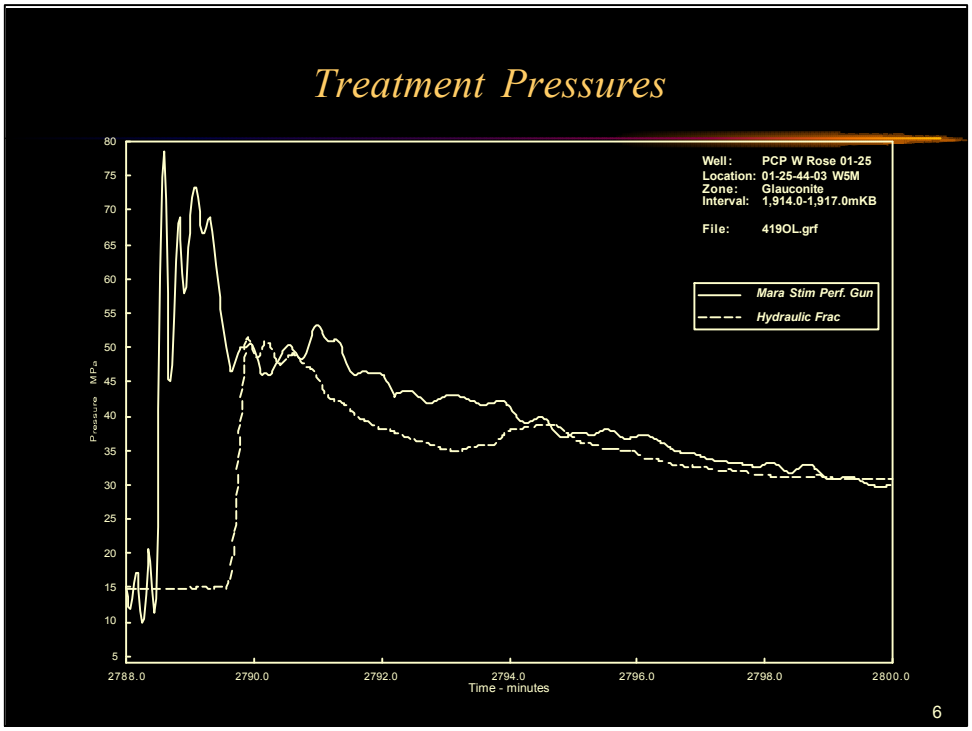


Overlay of a perf gun and a propellant tool across the same zone. The duration of the perf charge pressure pulse is ~10 microseconds (results in pulverized rock),the propellant burn can last up to 500 milliseconds (produces and extends cracks in the rock).

Pre Frac Treatment

- Propellant treatment greatly improves hydraulic fracturing. We ***Do Not*** recommend propellant treatment as a replacement for hydraulic fracturing.
- There are some cases where fracs have been rendered unnecessary.
- There are many more cases where hydraulic fracturing would be difficult or impossible without propellant pre treatment
  - >200 wells in the Algeria (SPE in StimGun book)

5



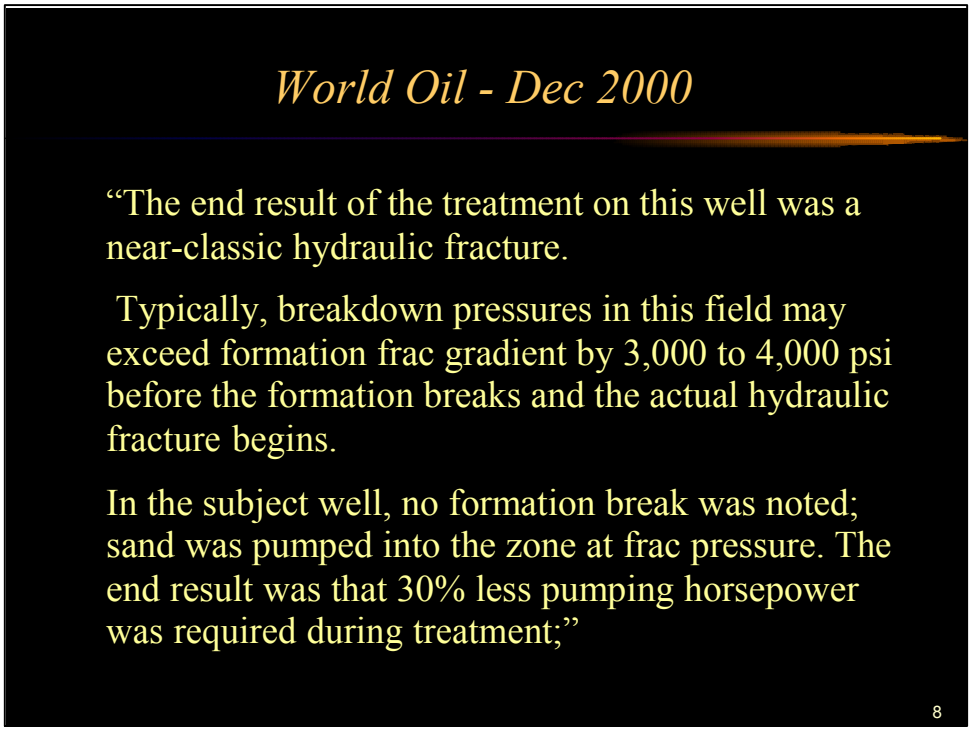
This overlay of recorded downhole pressures of a Stim Gun assembly pre frac treatment (in milliseconds) and a hydrauluic frac (in minutes) in the same zone. After the initial breakdown the extension pressure is very similar. Propellant treatment improves hydraulic fracturing by breaking down the perfs and initiating fracs where desired (we do not recommend propellant treatment as a replacement for hydraulic fracs - the time window we work in generally limits fracture extension to 2-15 ft.).
Although we have many case histories of fracs being eliminated (usually small or batch fracs) we have as many or more cases where hydraulic fracturing would be impossible without a pre frac stimulation - >200 wells in Algeria (see SPE paper in StimGun book).

Pre Frac Case Histories

- Propellant stimulation improves hydraulic fracs
- The following examples include completions in:
  - Hard rock
  - Soft rock
  - Deep
  - Shallow

see the StimGun book for more

7

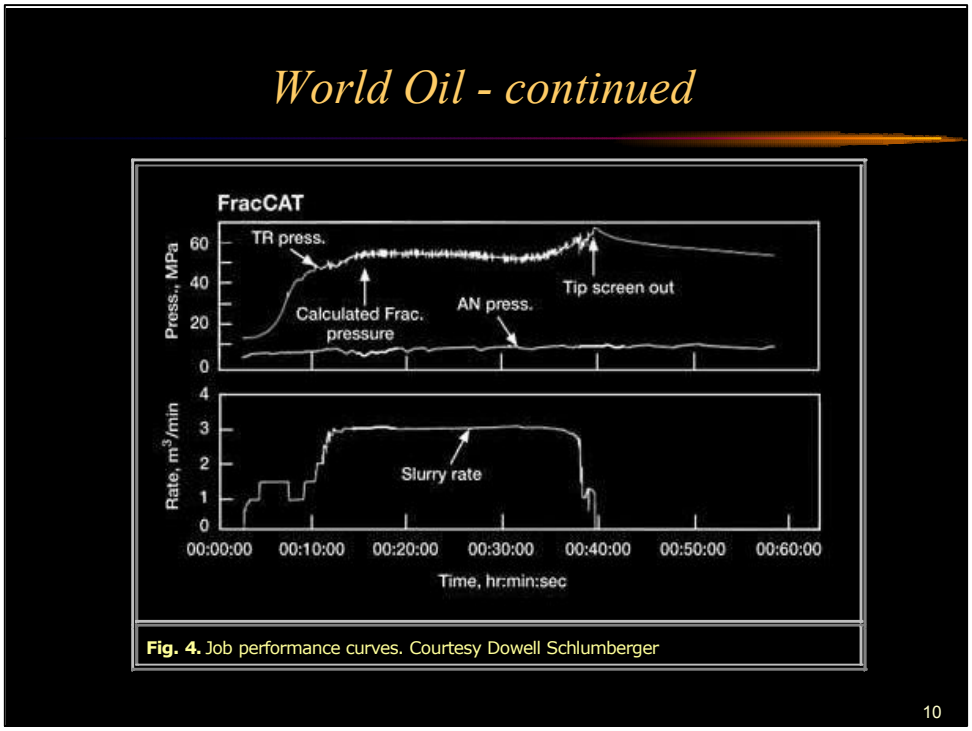


An article about frac results in a "hard rock" well in the same area as well in slide 6. It can be more effective and less expensive to use the propellant burn to produce pressures 3000-4000 psi above frac gradient to initiate breakdown than to use pumping pressure from surface.

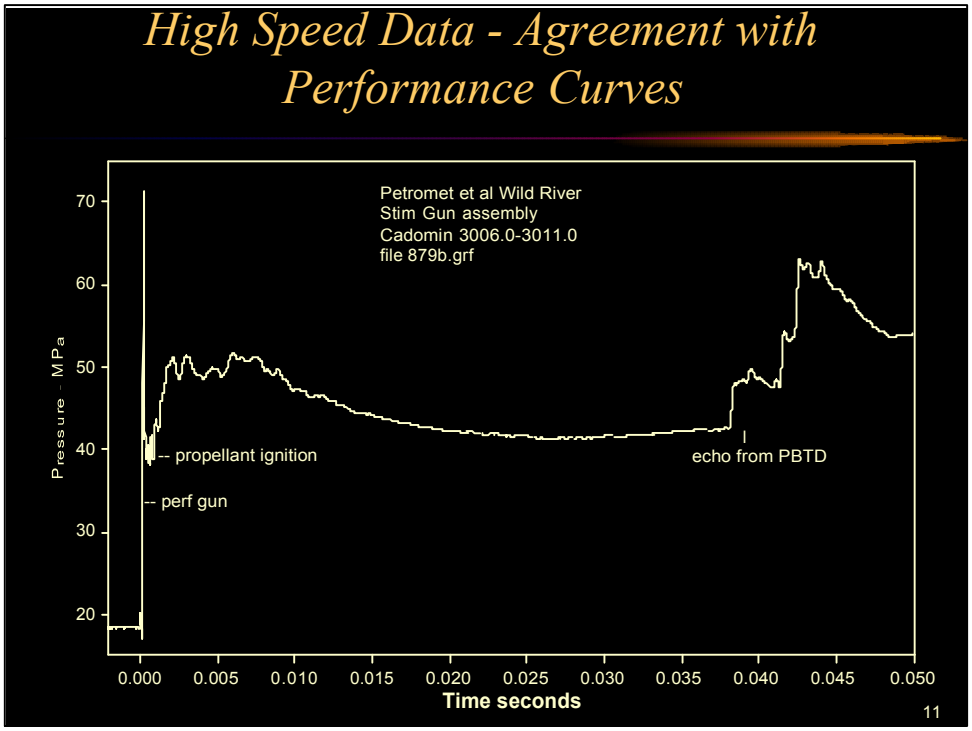
World Oil - continued

"calculated frac gradient was 55 MPa (7,900 psi). As shown on the performance curves, Fig. 4, the pumping operation began at 55 MPa and continued until screenout. In all, 25,000 kg (55,000 lb) of carbo-prop were placed in the formation. In summary, Stimgun eliminated a potential stimulation problem, resulting in an improved well completion." [WO]

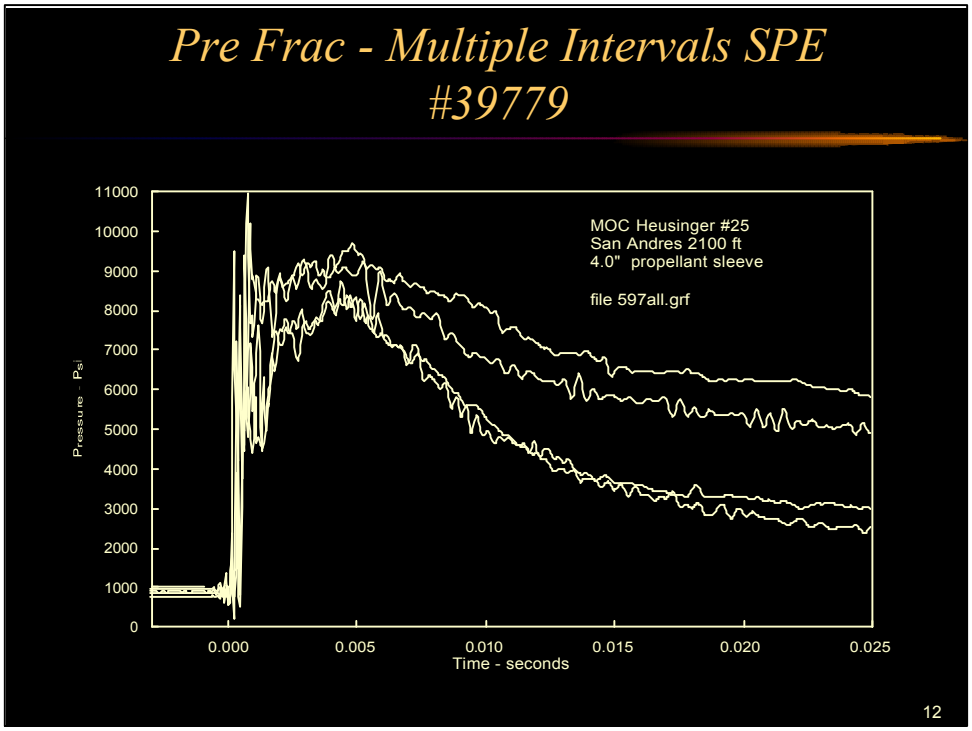
9



Job performance curves (provided by Dowell Schlumberger) of a "classic hydraulic frac" after a StimGun pre frac treatment

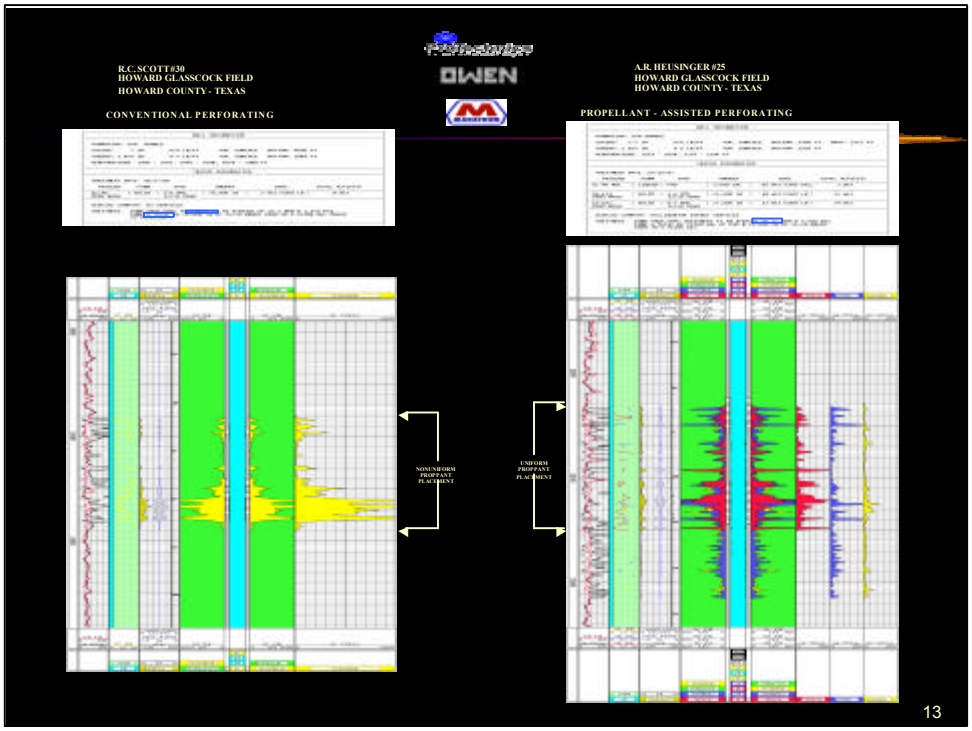


High speed data recorded in the same formation (offset well) is in agreement with Schlumberger's performance curves. In a properly designed pre frac application the pressure response will be determined be the frac gradient and a short bi wing fracture in the hydraulic frac plane will be the result.
When too much propellant is used the peak pressure can be many times the frac gradient and multiple off plane fracs can also be created – this might be good for. primary production but not as a pre hydraulic frac conditioning.



Multiple or long intervals more often than not have varying permeability or other factors which affect hydraulic breakdown and extension - as pumped fluids follow the path of least resistance.
Propellant pre treatment will improve the consistent placement of proppant throughout multiple or long zones and can be used to control frac initiation to certain areas (up to 13 frac initiation spots have been simultaneously created in horizontal wells).

In this field the deeper intervals have higher perm - as shown by the lower peak pressure and faster fall off during propellant stimulation

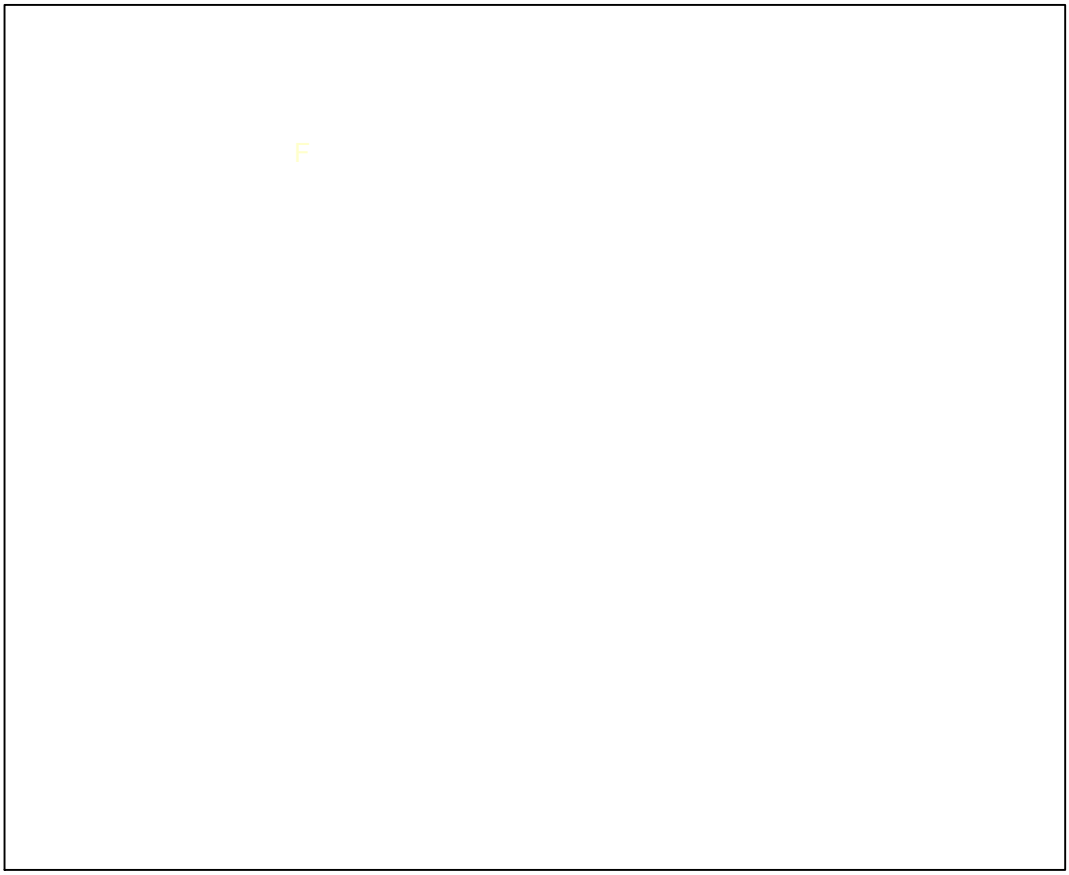


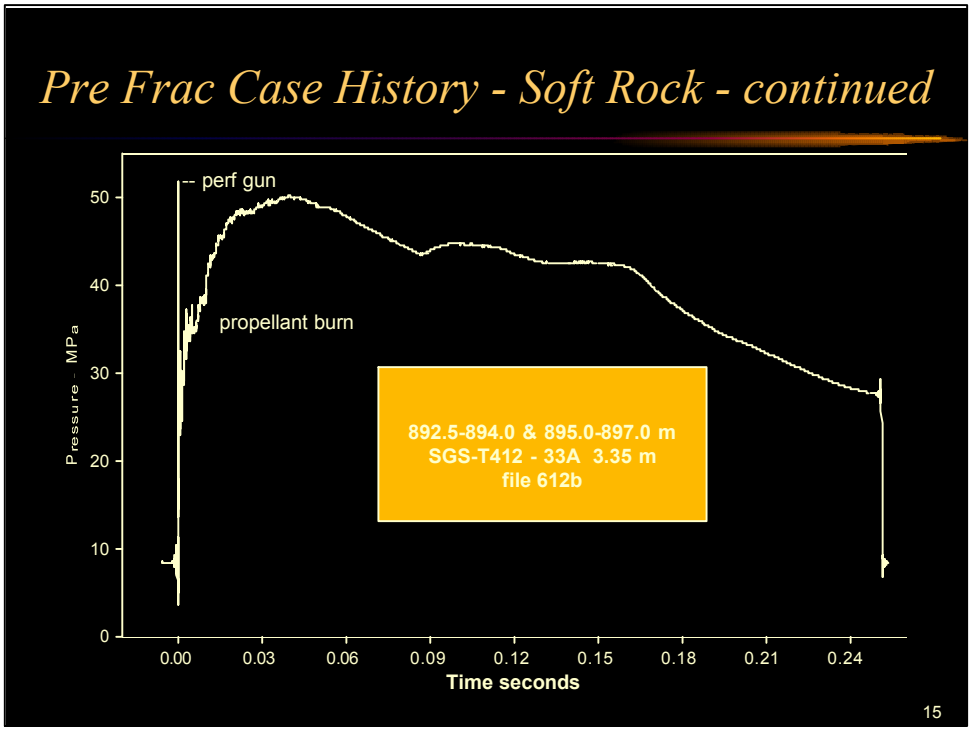
Tracer logs show the tendency for the higher perm zone to preferentially take proppant before screenout. Consistant proppant placement is seen in the well pretreated with propellant which resluted in production 25% higher than field average.

Pre Frac Case History- Soft Rock

- Bakken Sandstone
  - Unconsolidated Sandstone / Siltstone Conglomerate
  - Cretaceous Period
  - Mannville Group of Sands
  - Average Depth, 2800’ (850m)
  - Average Porosity, 30%
  - Average Perforation Interval, 10’ (3m)
  - Average StimGun Coverage, 8’ (2.5m)

14



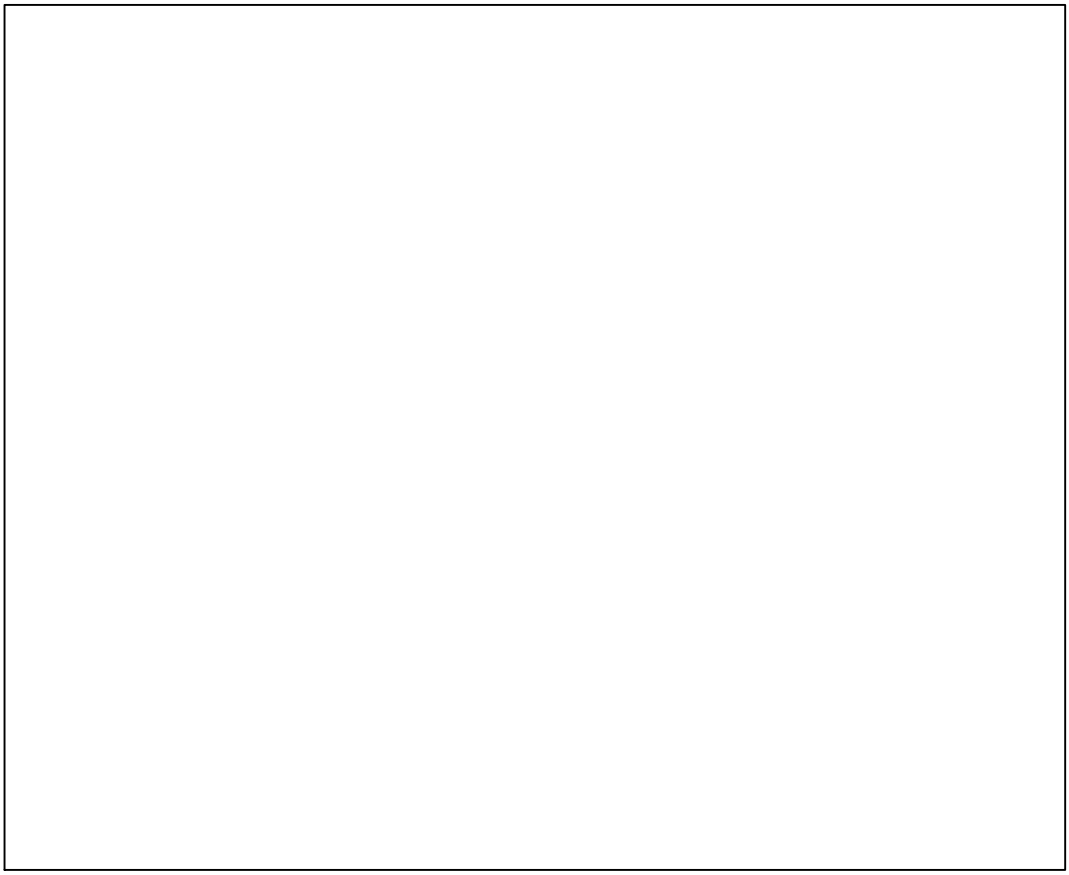


typical shallow sand pressure response

Pre Frac Case History - Soft Rock - continued

- The client has confirmed the following:
  - In wells with porosity >30%, fracs have been eliminated.
  - Average frac cost for these wells, $25k, 15 tons.
  - Wells where fracs were required, fracs broke down much easier and went away far cleaner.
  - Of the first 16 wells, 12 required no frac, saving the client $300k
  - More than 300 wells completed in this field to date

16



Pre Frac Treatment -- Conclusions

- It can be much cheaper, and sometimes more reliable, to break down perforations and initiate fracs with chemical energy than than with hydraulic horsepower.
  - The extra cost during perforating is insignificant compared to hydraulic horsepower costs or improved production results.

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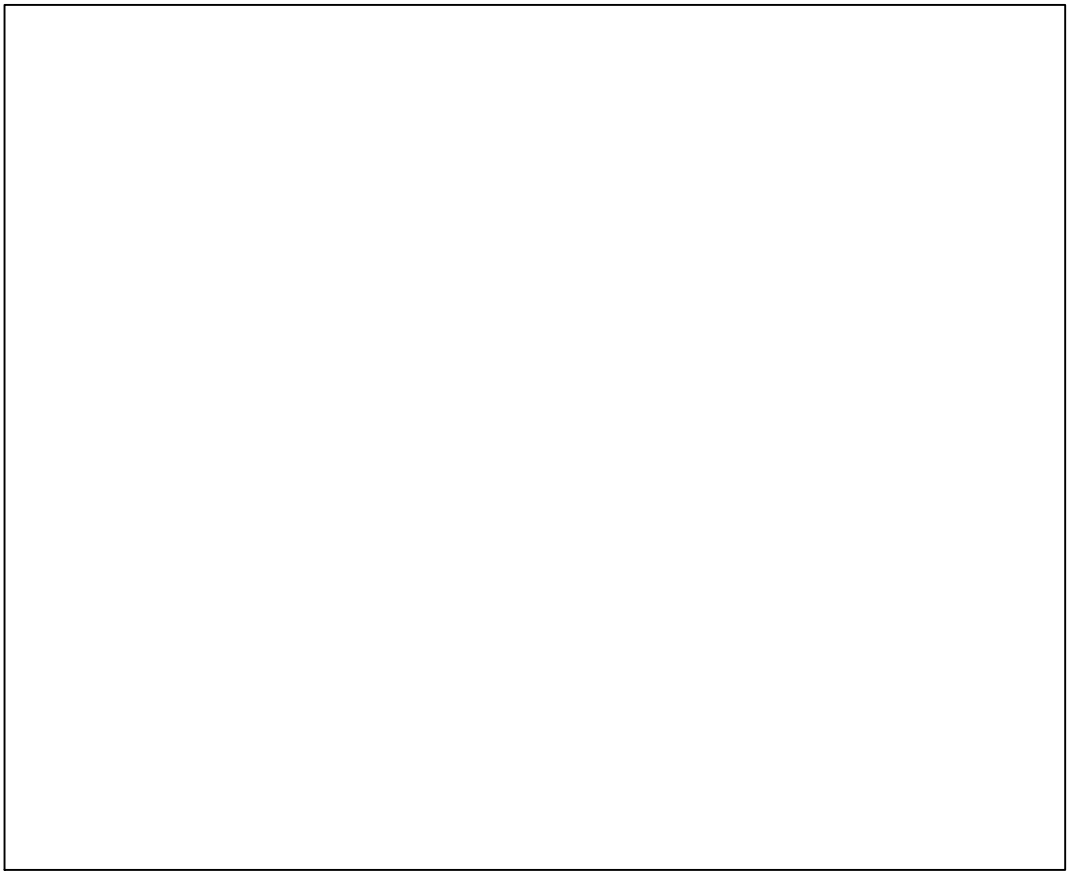
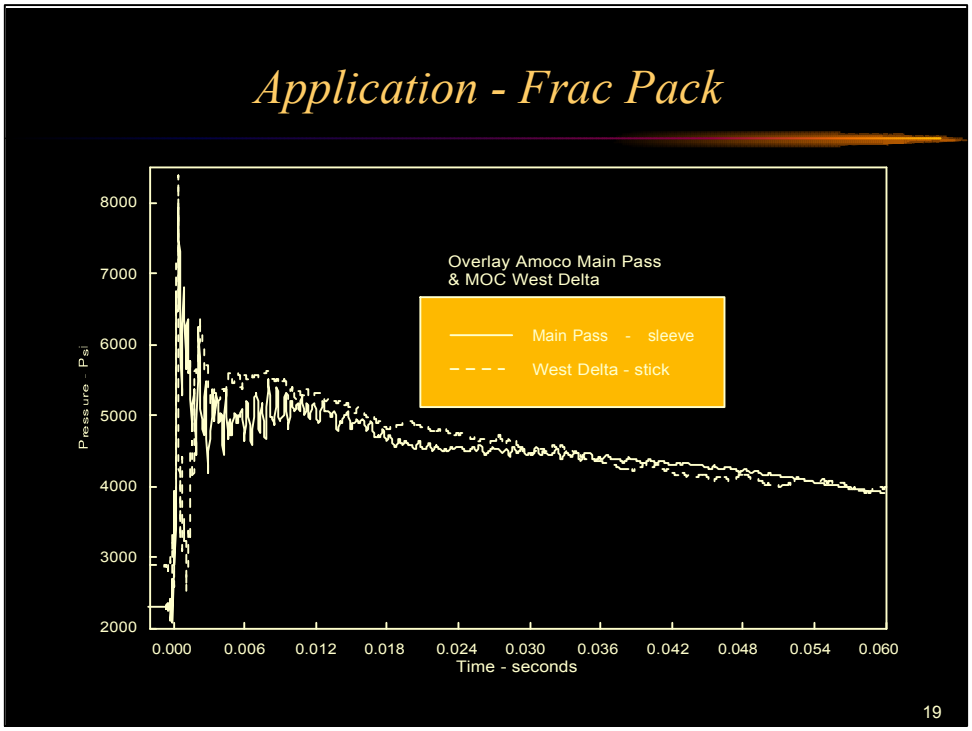
Application examples - Gravel Pack

- Gulf of Mexico
- Early wells for MOC and Amoco
  - High perm soft sands at 6000-8000 ft showed production improvement. 560 bbls/d vs 250.
- Spirit
  - at ~10000 ft resulted in higher fluid losses after perforating than they had ever seen. The fluid loss was close to what the formation was theoretically capable of.

18





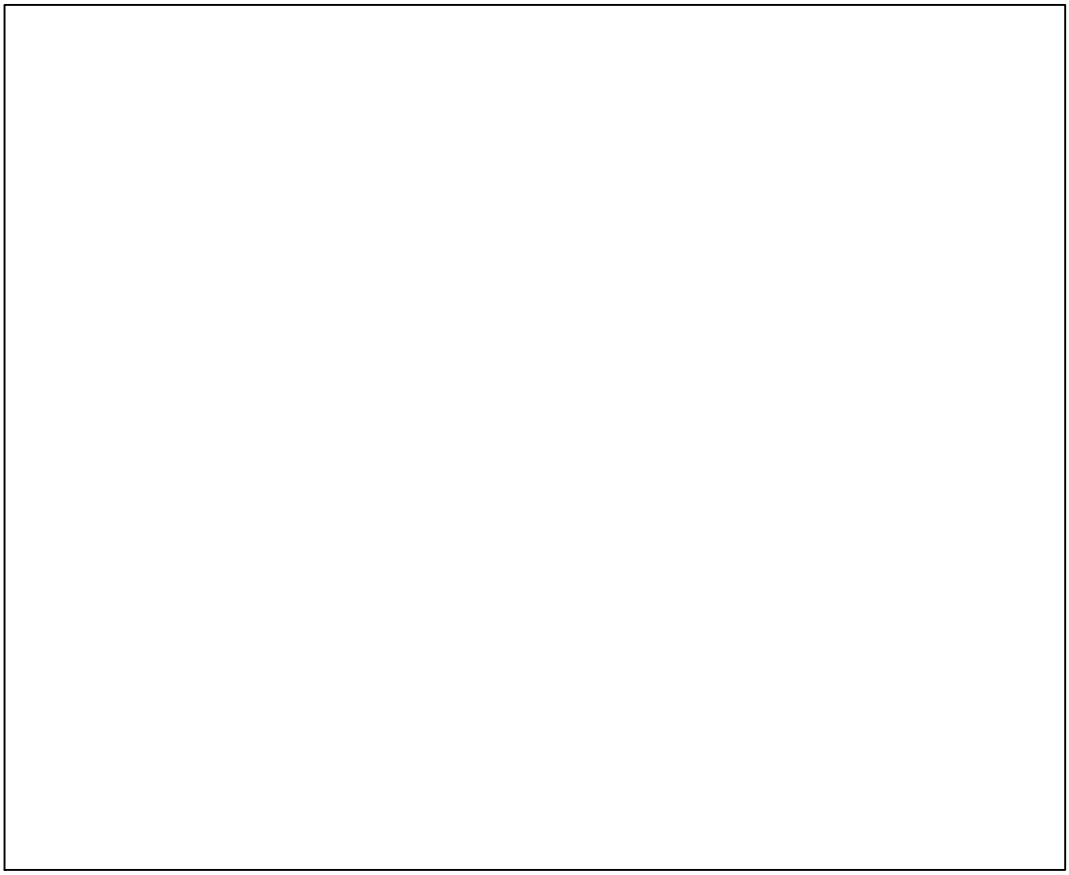
Successful Gravel Packs and Extension Packs in the Gulf of Mexico have resulted in improved sand placement and production.

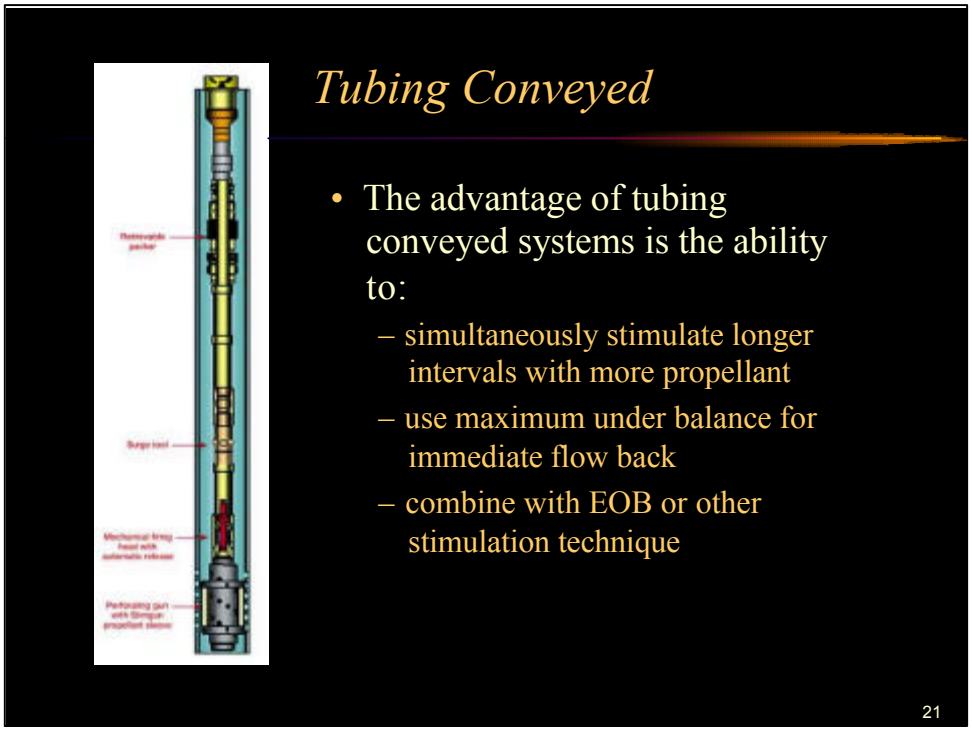
Pressure response overlay of a Stim Gun assembly and WST stick propellant in similar high perm sands in the Gulf of Mexico.

Application -- Extension Pack

- Gulf of Mexico - StimGun w/ 4 5/8", 12spf SH charges
- Deepest reported job to date
- Job Details:
  - Overall Interval- 22403' - 22672'
  - Top Shot- 21863' TVD
  - Packer Plug- 8ft from bottom shot
  - Casing- 7 5/8", 39#/ft, P110
- Results:
  - The extension pack was designed for 45000# of sand placement. Screen out occurred at 42500# during the 4#/gal stage which was a considerable improvement from the previous attempts which screened out at the 1 or 2#/gal stage placing ~12000# . Sand placement in subsequent wells utilizing more sleeve coverage and longer intervals has reached up to 250000#

20



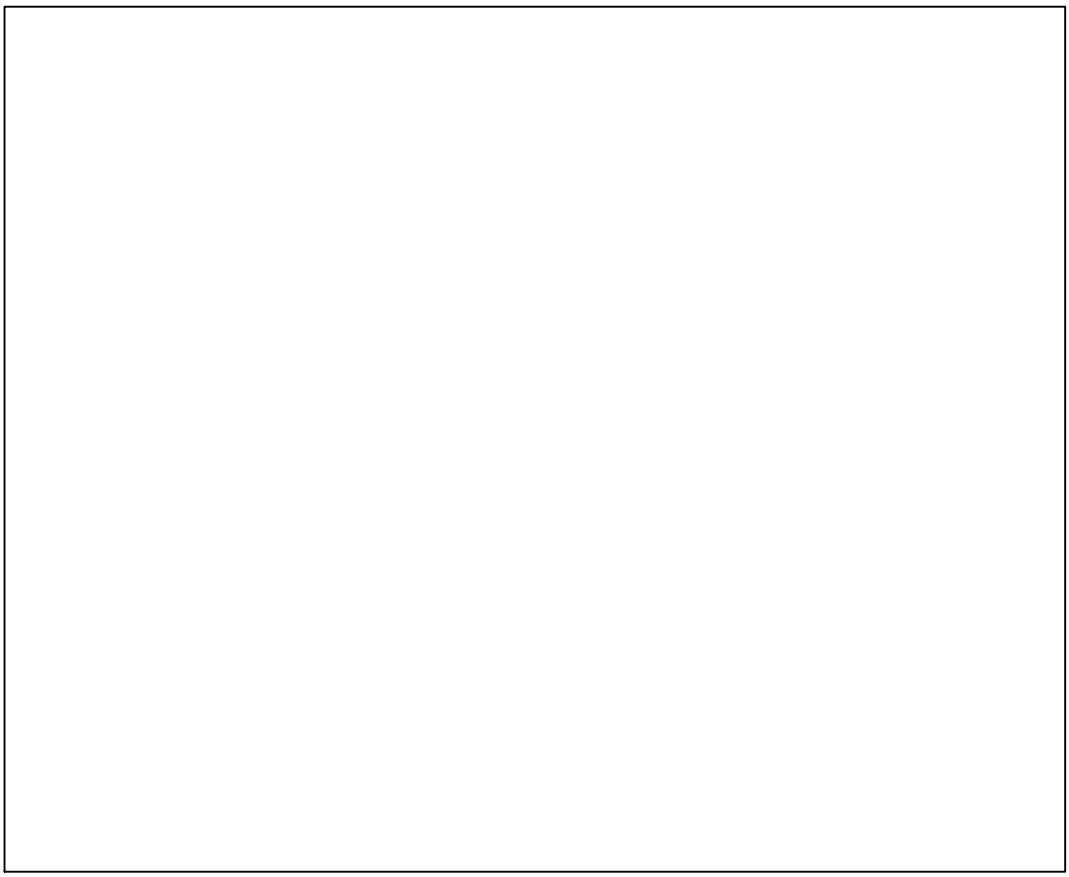

Tubing Conveyed
The advantage of tubing conveyed systems is the ability to:
– simultaneously stimulate longer intervals with more propellant
– use maximum under balance for immediate flow back
– combine with EOB or other stimulation technique
21

Tubing Conveyed - Oils wells - Egypt

The wells selected for trial had good productive potential and were in homogeneous, well known reservoirs. Stim Gun assemblies were run tubing conveyed, natural completions. Most in new completions.
Early results were excellent and the project rapidly expanded to include new completions from 1200 to 12000 ft.

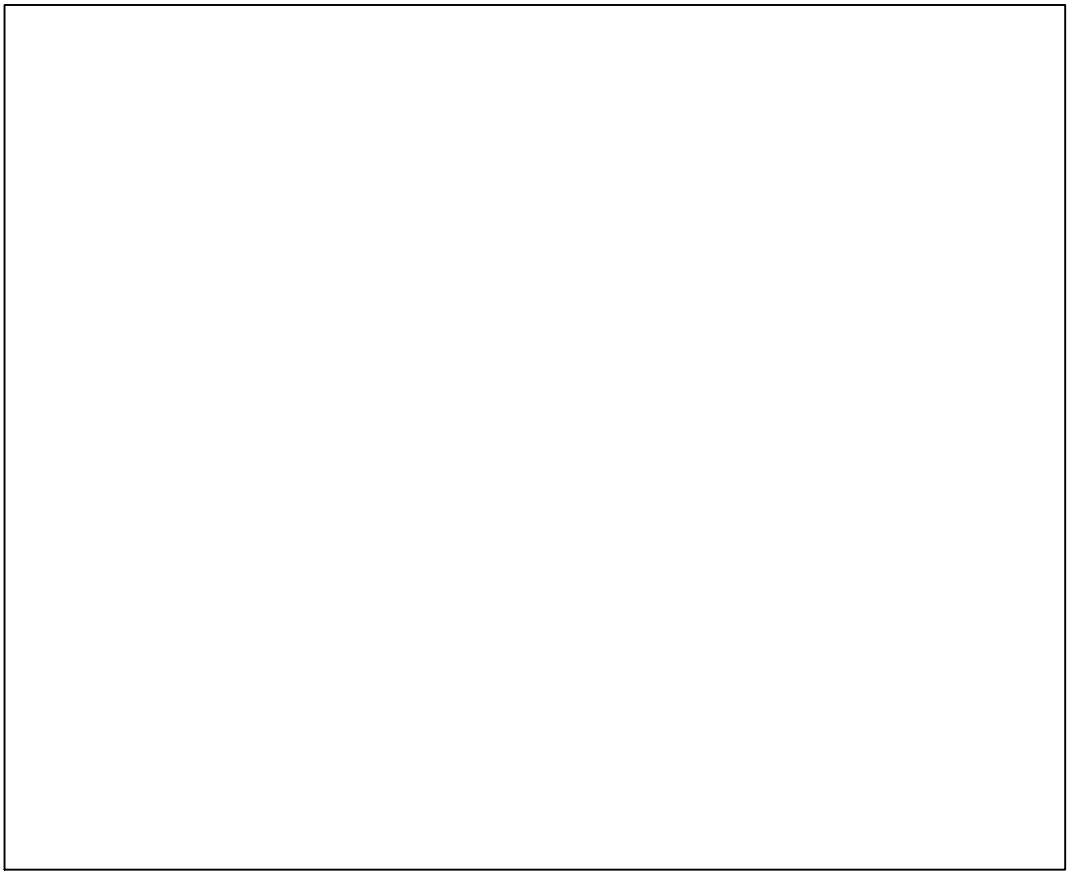
Pressure transient tests were performed on many of the wells the results showing 0 to -4 skin values. Production ranges from 2-4 times that of previous completions.

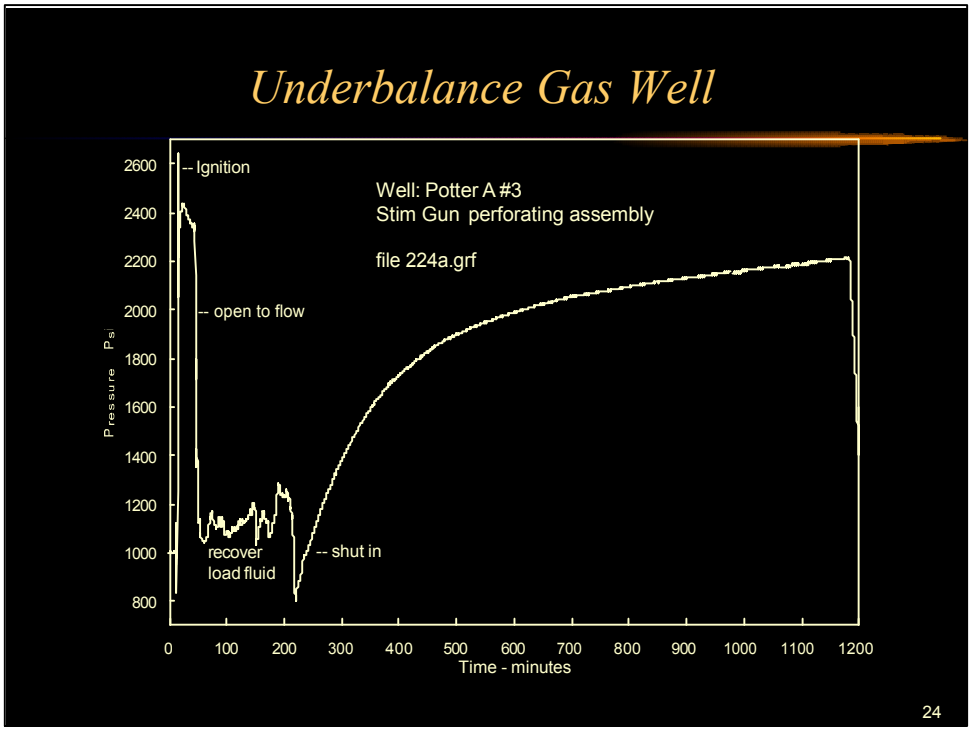
22



Tubing Conveyed Underbalance Gas

- This may be "the best way to complete a gas well" as the stimulation is followed immediately by flow which provides additional perf cleanup.
  - Shallow
    - 6 wells for MOC in Wyoming from 1200 ft - 1800 ft - production rates up to 3x other completions
  - Medium
    - MOC Canada, Texas, Alaska - 4000-8000 ft. low skin completions in Morrow, Viking and Beluga - all fluid sensitive sands - all completed with low skin and good production

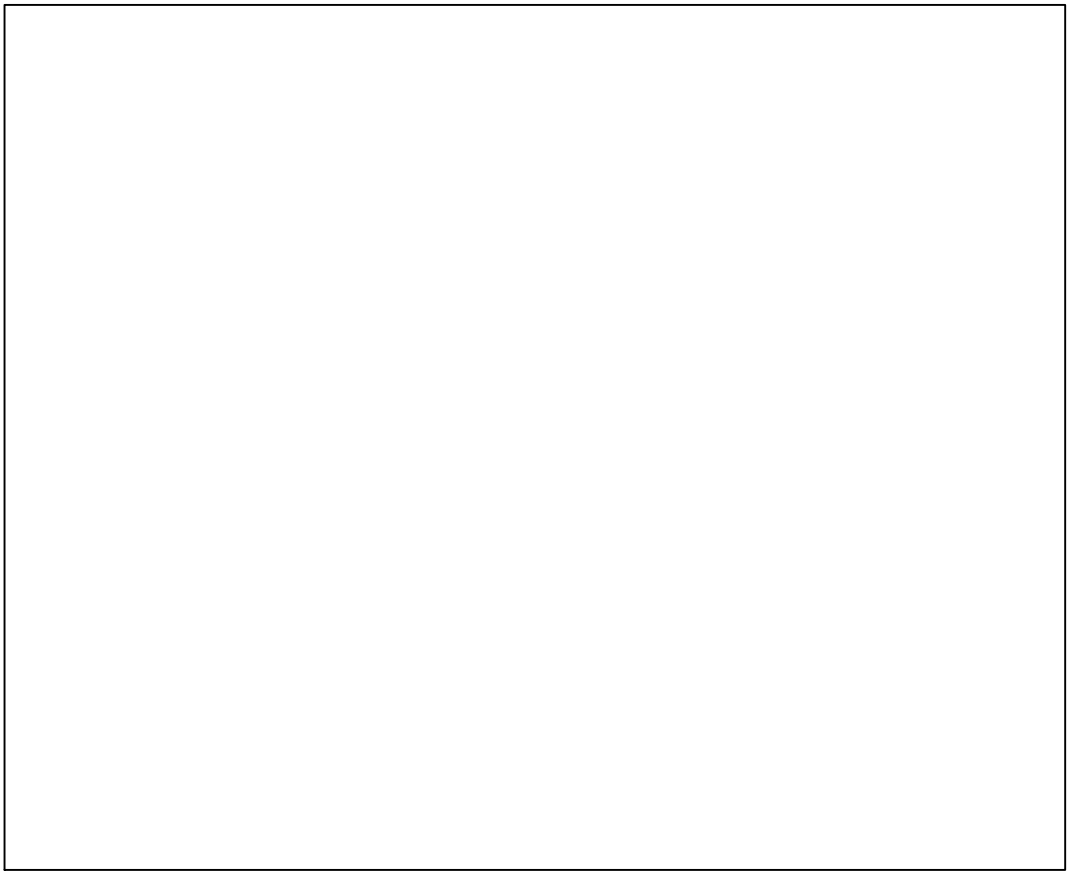


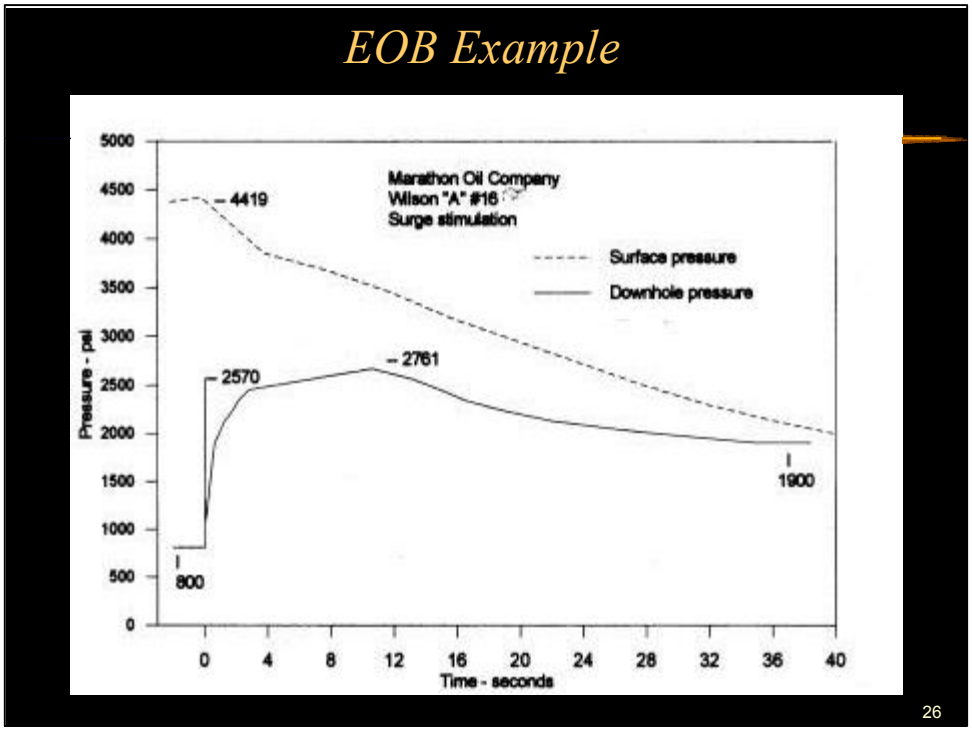

Underbalance Gas Well
-- Ignition
Well: Potter A #3
Stim Gun perforating assembly
file 224a.grf
-- open to flow
recover
load fluid
-- shut in
Pressure Psi
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Time - minutes
24

EOB-Stim Gun Combination

- New York - Propellant used in conjunction with extreme overbalance perforating and proppant carriers.
  - 10,500 psi surface pressure when guns fired - 1.4 psi/ft
  - 1,200 gallons on HCL injected after EOB at 3,000 psi less than offset wells
  - Offsets produce 1 MMCFD, this well-5.5 mmcf
  - Offsets were completed with extreme overbalance perforating and proppant
- Project continues
  - 12 wells to date up 7 mmcf.
- Now used in Pennsylvania, Oklahoma, Texas, Canada

25





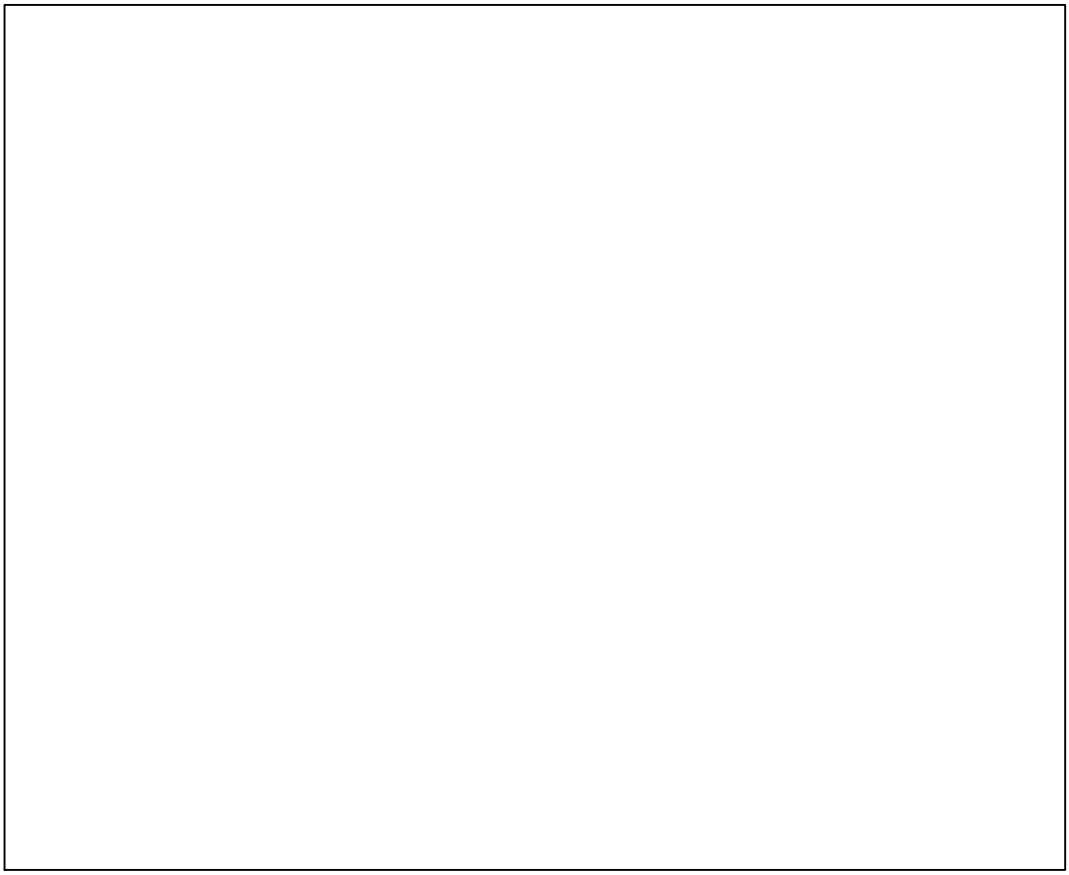
EOB example

Surface pressure and down hole pressure of an overbalance surge stimulation - the relatively slow pressure load rate will lead to the breakdown of fewer perfs than a propellant stimulation. Although the extended time of the surge will lead to an increased radius of stimulation. These data were used to design more effective surge tools and improve EOB stimulations. The addition of StimGun greatly increases job efficiency and well productivity – see Expro case histories

Near Gas/Oil/Water Contacts

"The short time in which pressure is applied limits fracture growth. The high pressure assures the stimulation does not follow the path of least resistance. Perforations are opened and the cracks do not extend out of zone. Mitchell case histories - wells previously completed with batch fracs led to 375 bbls oil 1000 bbls H2O - 12 wells with propellant 450 bbls oil 50 bbls water. Probe Canada case histories - 12 wells - replaced skin fracs. Small acid jobs have also been replaced or enhanced by using propellant first or shooting in acid."

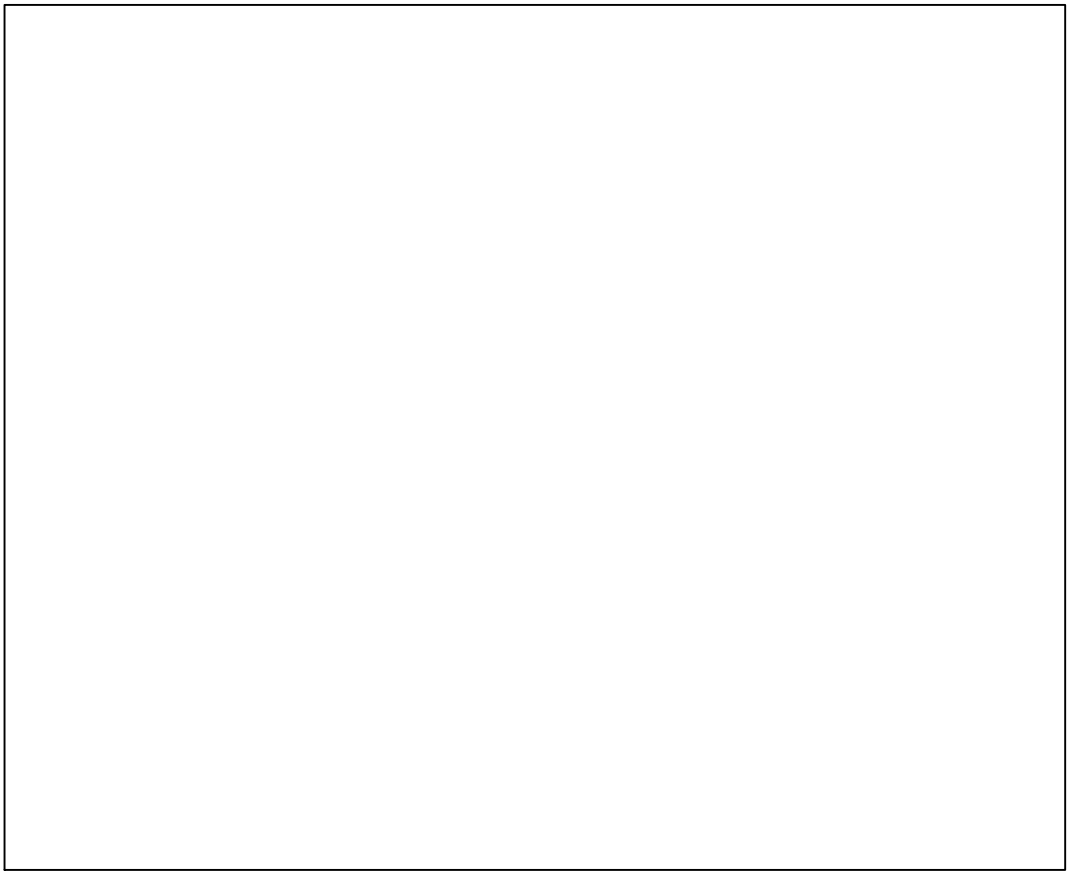
27

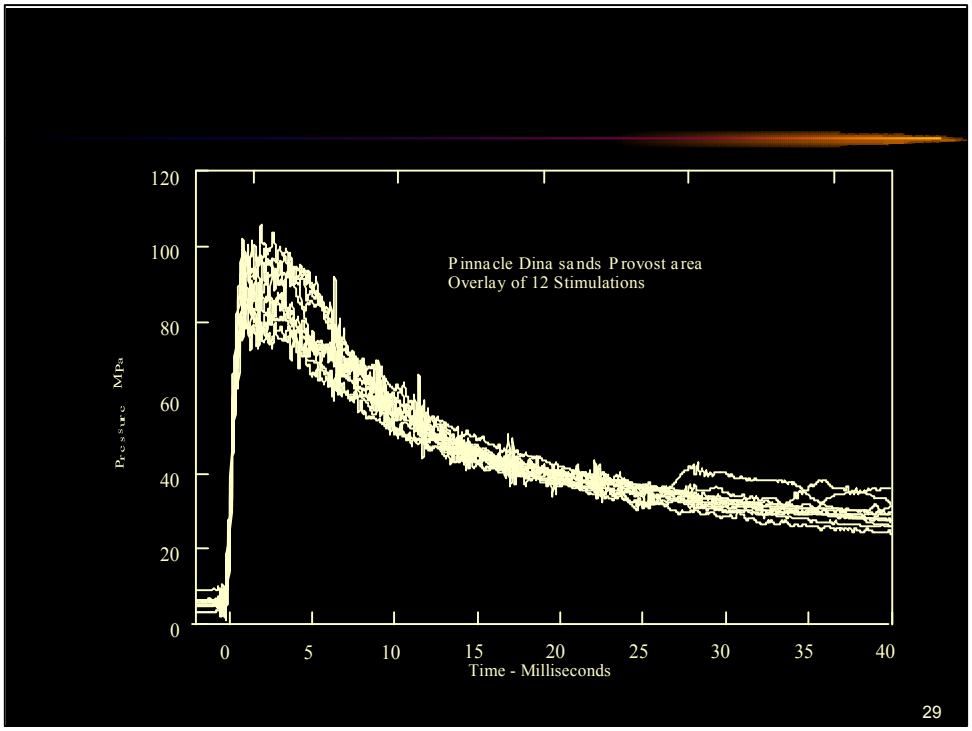


Medium Depth Medium Oil wells

"More mundane but a large portion of our work are the day to day ordinary oil wells. Although the results are not spectacular they more than cover costs. In some fields, where positive results have been established, using propellant becomes the routine completion. The following slide is an overlay of the first dozen shots in the Dina formation (>300 wells to date) - Western Canada - the pressure response is very repeatable as is the incremental production - always 25%."

28




Pinnacle Dina sands Provost area
Overlay of 12 Stimulations
Pressure - MPa
120
100
80
60
40
20
0
0
5
10
15
20
25
30
35
40
Time - Milliseconds
29

Stripper Wells and Low Pressure Formations

- Low drive oil formations are much more sensitive to perforation and near-wellbore flow restrictions
  - Problems caused by migration of fines, emulsions, wax, asphaltines and precipitates all have correspondingly more severe effects in low pressure
- Propellant stimulation should be considered:
  - Any time a workover is scheduled
    - pump change, reperforate, etc.
    - It is usually NOT economical to move a rig on to a low producing well for propellant stimulation only
    - Low drive also means low production. Typical production increase is 8-30 bbls day
  - As a pre abandonment evaluation "last kick at the cat" - low chance of success but good payback
  - When there are adequate perforations in the casing, StimTube or WST should be used. If not, or when in doubt use a Stim Gun assembly.
- We have dozens of case histories in Texas, Wyoming, Montana, Canada…. where production increased from 100 to 800%. Although this usually ~6 to ~40 bbl/d

30

Heavy Oil

- More than 600 wells in Canada
  - Shallow unconsolidated sands
  - SPE # 37531
  - Payback average 6 weeks (includes rigs, pumps, etc.)
- Indonesia
  - Sumatra wells at 6000 ft show incremental production of 300 to 600 bbls/d
- California
  - A 1000 ft StimGun assembly produced the first naturally flowing horizontal well in the field

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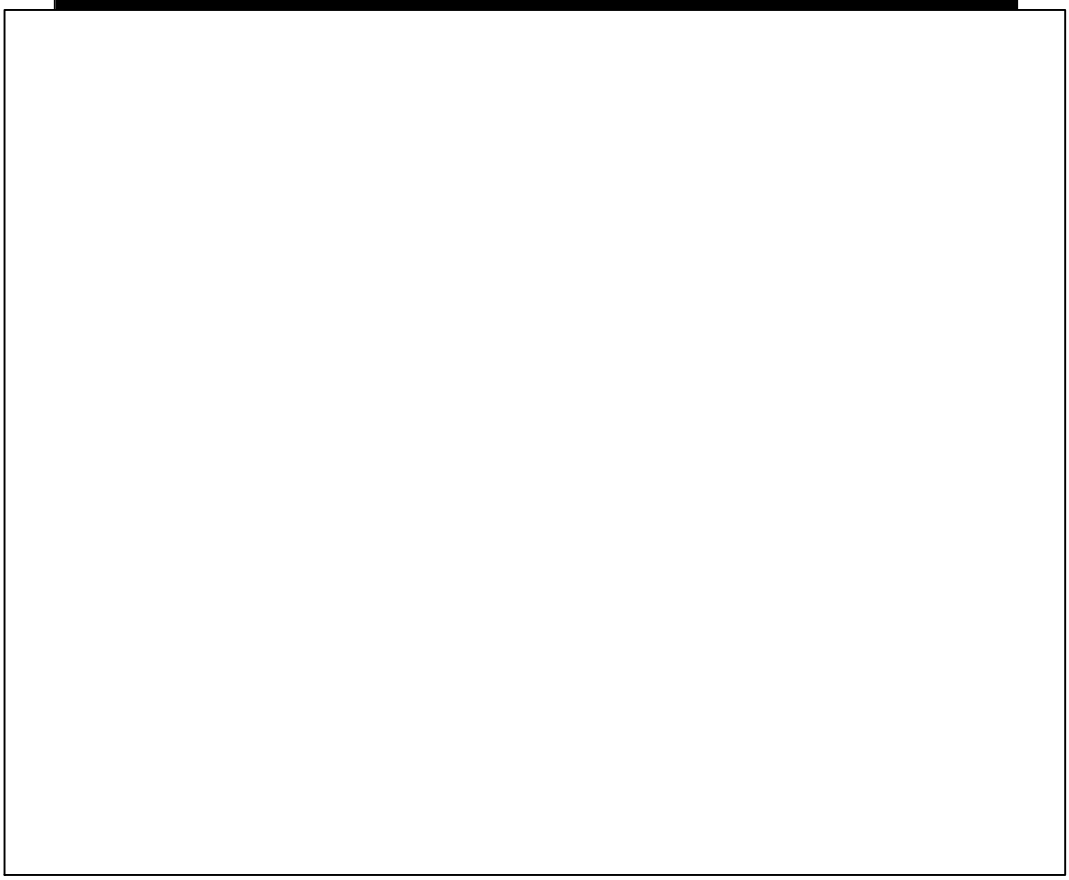
Horizontal Wells

- Horizontal wells usually do not produce near their capacity or require massive hydraulic fracs. .
- Propellants (sleeve or stick as appropriate) can breakdown perfs or open hole and produce mild fracturing over very long intervals or initiate fracs in just desired locations.
- Open hole FMI logs indicate that substantial breakdown lengths can be achieved with short sections of propellant (StimGun book).
- All horizontal well candidates should undergo a careful design procedure to identify areas most likely to produce and apply the proper amount of propellant.

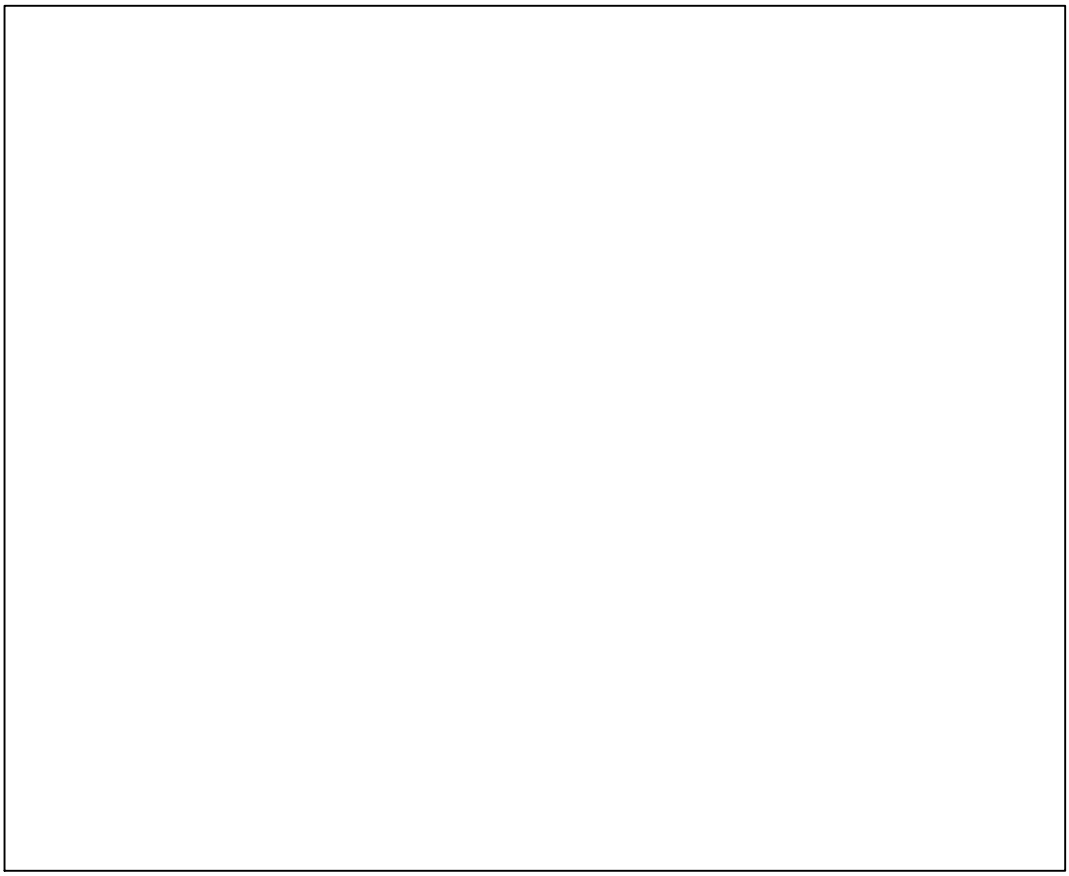
32



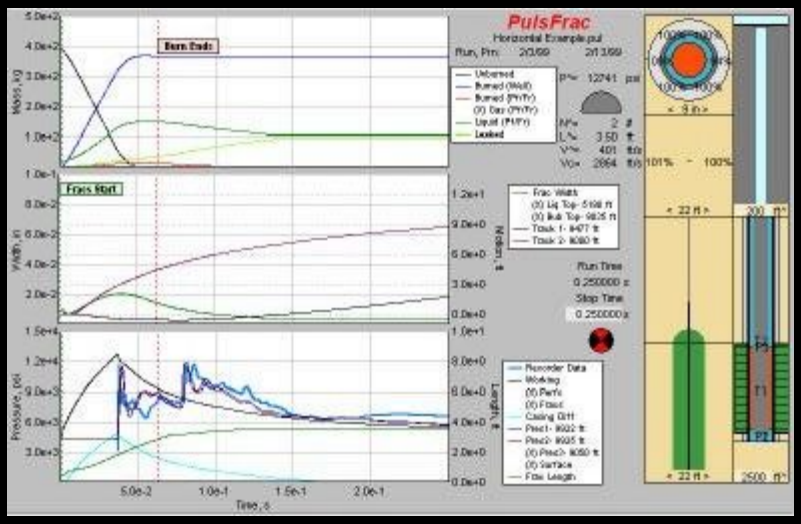
Horizontal Wells -- Previous Experienc

- We have treated a relatively small number of horizontal wells (35) but have seen very encouraging results.
- Successes occur when conditions are right (perm or natural fracs are present, and good job design is performed).
- Lack of success can be traced to bad formation, poor design (excessive tool size is too common by other companies), and/or bad post-treatment that re-created damage.

33



900 foot StimGun Assembly in Horizontal Hole

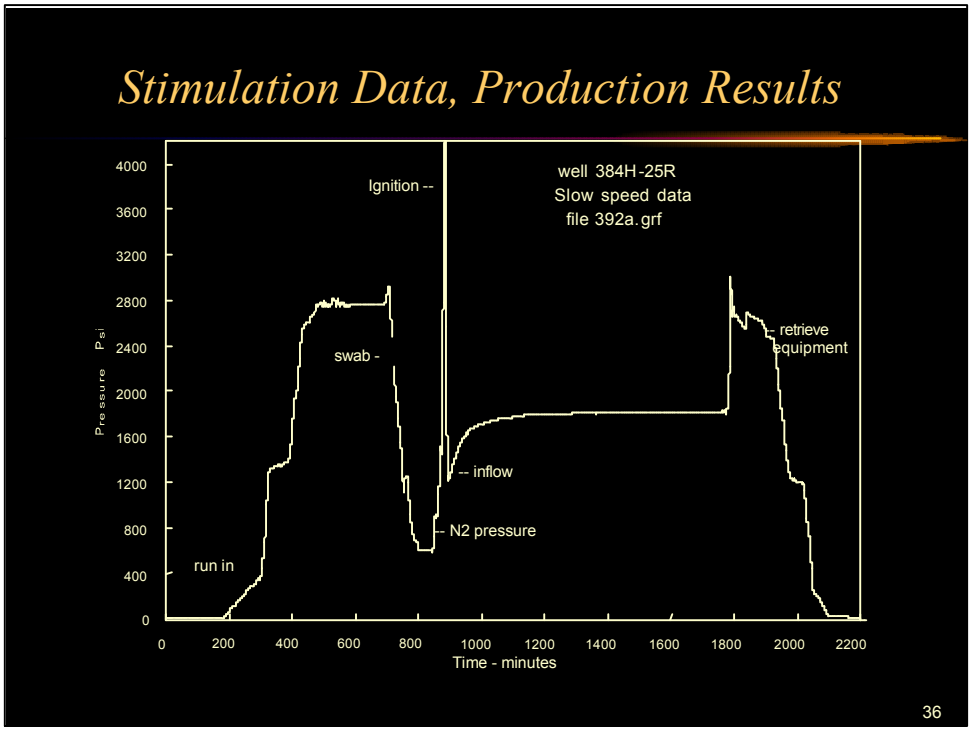


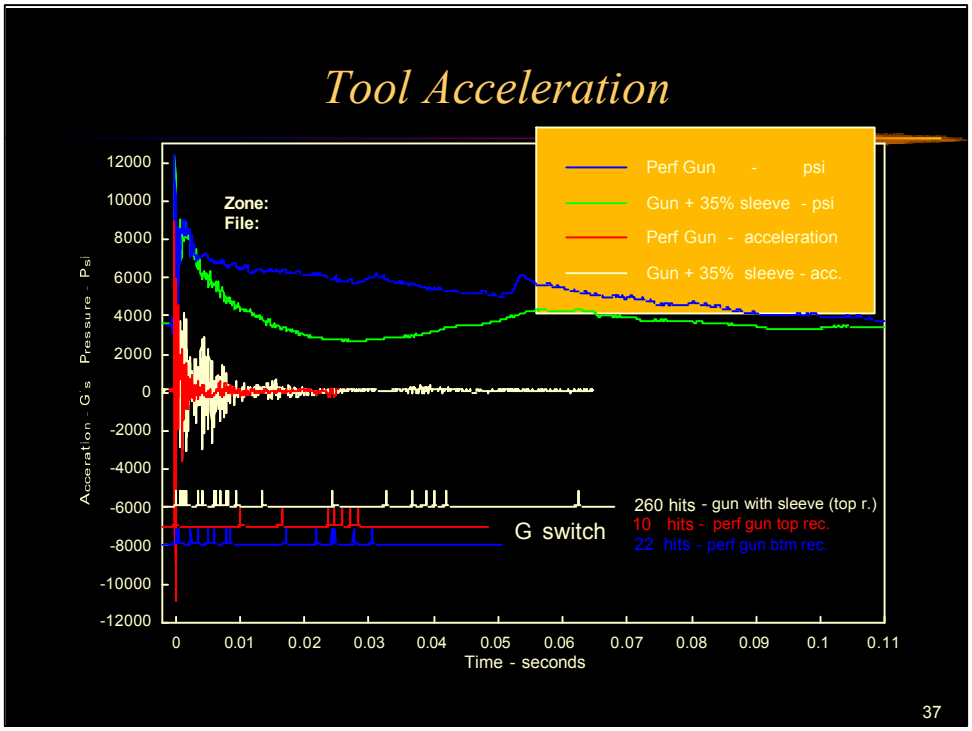
34

Naturally Fractured Wells

- The effective radius of stimulation of natural fractures can be considerably longer than created fractures. Considerable increased production has resulted.
- In a California well "the operator felt the increased production was well above anything that could be attributed to a near well bore stimulation. The operator is reluctant to release detailed flow rates which may be disproportionately high due to some unknown mechanism" SPE #56469
- In South America a well reperforated with a Stim Gun assembly showed incremental production of 5 mmcf, this increased again after an acid job

35


Stimulation Data, Production Results
well 384H-25R
Slow speed data
file 392a.grf
Ignition --
swab -
-- inflow
-- N2 pressure
run in
-- retrieve equipment
Pressure Psi
4000
3600
3200
2800
2400
2000
1600
1200
800
400
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
Time - minutes
36



This overlay of a perf gun and a Stim Gun assembly across the same formation (different wells) in a naturally fractured reservoir shows no additional pressure from the the large volume of propellant but a lot more accelerometer activity and a faster gas bleed off, indicating excellent connectivity established to the natural fracture system.

Injectors

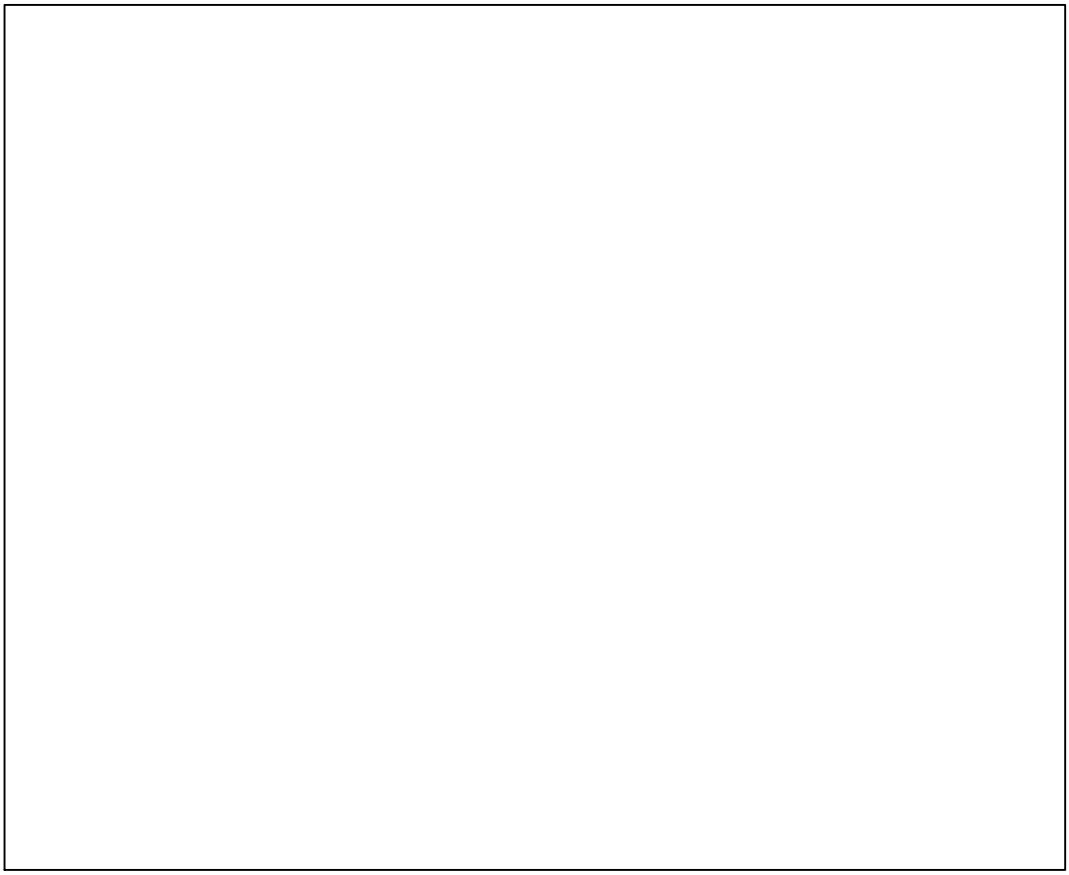
- In producers with scale damage Propellant can easily breakthrough damage but will not prevent the rescaling of the well. Similarly in injection can be initiated or reinitated but propellant will not prevent replugging.
- Sustained incremental injection of 16500 bbl/d was achieved in the first application in the Norwegian North Sea. (145 ft Stim Gun assembly run on wire line).
- Incremental injection of 7000 bbls day was decreased to 0 in an African job when the filter could not keep up so the operator bypassed it.

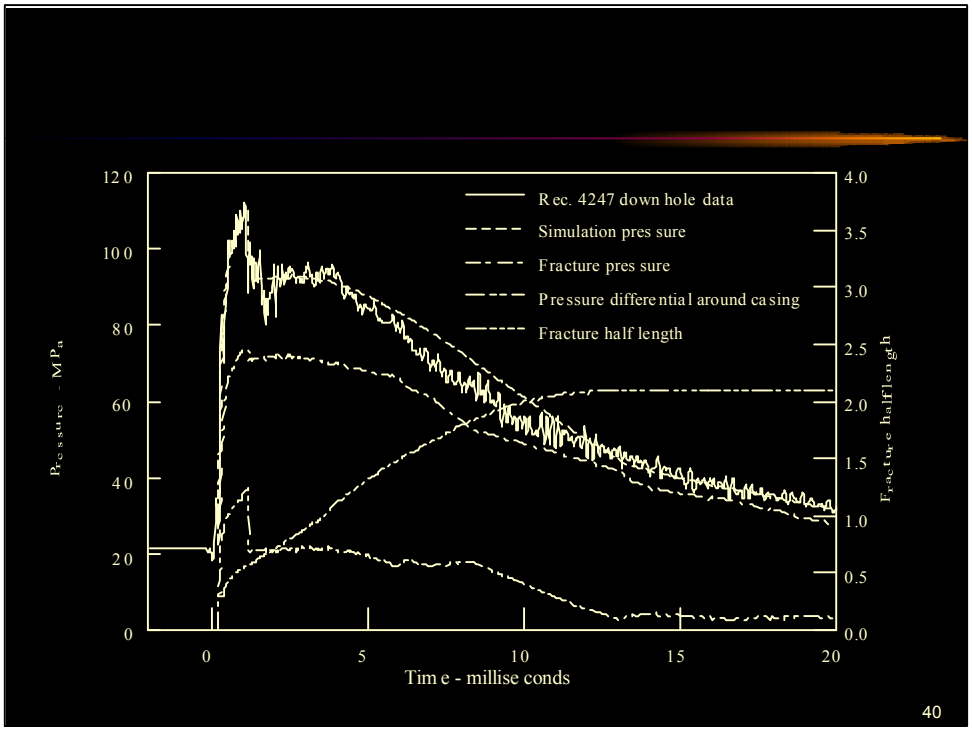
38

Polymer Injection – Open Hole, Sweep Efficiency

- Read SPE #38789 - sweep increased - production increased (best well) from 31 BOPD & 2450 BWPD to 194 BOPD & 2250 BWPD
- Sweep in open hole - Canada - Carbonate low perm top section, high perm bottom. Pre production - 200 BOPD & 5400 BWPD - Sustained Post production - 800 BOPD & 4800 BWPD. Normal production decline for the next four years – see StimGun book

39




Rec. 4247 down hole data
Simulation pressure
Fracture pressure
Pressure differential around casing
Fracture half length
Pressure - MPa
Fracture halflength
Time - millisecons
0
20
40
60
80
100
120
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
5
10
15
20
40

opppo

Summary

- Use Propellant to insure good connection to the reservoir
  - Perf Breakdown: >95% success
  - Economic method of pre frac preparation.
  - Superior tubing conveyed completions, both under and over balance, for oil wells or new gas completions.
  - Everyday oil wells, Heavy oil and Strippers
  - Horizontal & Open Hole Applications
  - Injectors, Gravel Packs, Polymer enhancement

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