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1

Appropriate Hydraulic Fracturing Technologies for Mature Oil and Gas Formations

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Today's Talk

- Understand the Reservoir First
- Get Value for Money
- Techniques for Mature Assets

+ Case Histories

3 of 39

Understand the Reservoir

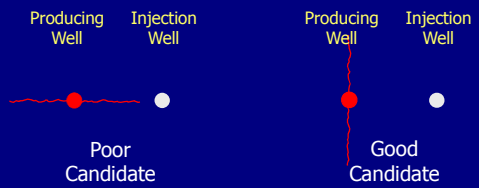
Understand the Reservoir

- Reservoir Engineering is a Necessary Part of any Mature Field Redevelopment
- Field Studies
  - Recoverable reserves
  - Economic justification
  - Fracture azimuth
  - Extent of water, steam or gas flooding
  - Potential for infill drilling

5 of 39

Understand the Reservoir

- Importance of Understanding Fracture Azimuth:-



6 of 39

Understand the Reservoir

- Production Well Studies
  - Reserves behind pipe, pressure
  - Potential for water production
  - Permeability!
- Establish Candidate Selection Criteria
  - Review and adjust regularly
- Injection Wells can be Fractured to Improve Sweep Efficiency
  - Economic justification usually harder

7 of 39

Case Study #1

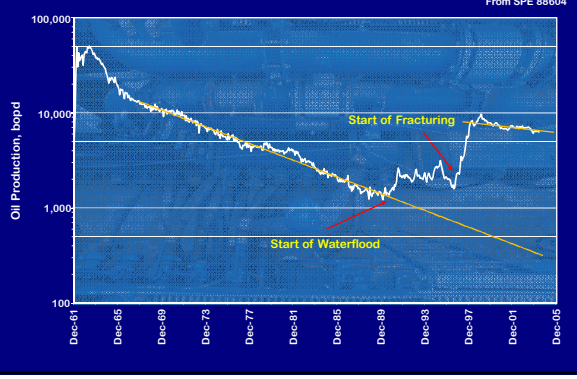
- Tanjung Field, S. Kalimantan, Indonesia
  - Mature oil field, first production 1961
  - Low pressure, medium permeability, shallow, multi-zone, ESP's
  - Fracturing used to redevelop field
  - Extensive reservoir engineering
  - Systematic approach to candidate selection
  - Simple, low-tech frac treatments

(ESP = Electric Submersible Pump)

8 of 39

Case Study #1

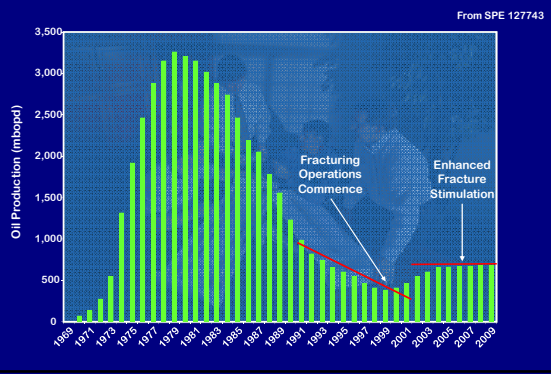
From SPE 88604



Case History #2

- Samotlor Field, Western Siberia
  - 55 billion bbls STOOIP
- Peak Production 3.2 mmbopd
  - 1980
  - Declined to < 400,000 bopd by 1999
- Fracturing Started in 2000
  - +/- 1000 treatments per year
  - Production stabilised at +/- 600,000 bopd

Case History #2



Get Value for Money

Get Value for Money

- Plan on a Field-Wide Basis, rather than Well by Well
  - High Volume = Low Unit Cost = High Value
  - Reduced per frac costs
  - Reduced day rate

13 of 39

Get Value for Money

- Get Appropriate Technology and Equipment
  - Use the right technology, not necessarily the latest technology.
  - State-of-the-art frac equipment = state-of-the-art pricing!
  - Keep it simple

14 of 39

Get Value for Money

- Pump the Right Sized Treatment
  - Don't pump large volumes of proppant just because you can
  - We need the right combination of length and width - too much propped width means wasted proppant

15 of 39

Get Value for Money

- Avoid False Economies
  - Use artificial proppant rather than frac sand
  - Be prepared to re-perforate
  - Get downhole pressure data
  - Be prepared to minifrac
  - Use clean fluid systems - Filtration!

16 of 39

Get Value for Money

- Give the Service Company a Reliable Scope of Work
  - The easier it is for the Service Company to plan ahead, the lower the cost of fracturing
  - Uncertainties increase Service Company risk and hence add to costs

17 of 39

Get Value for Money

- Low Cost Workovers
  - To get maximum effect from hydraulic fracturing, it is usually necessary to perform some sort of workover prior to fracturing
    - Zonal isolation, removal of ESP's, fishing etc
    - Completion may be unsuitable for fracturing
  - Most Successful Mature Field Projects have had Access to Low Cost Workovers

18 of 39

Techniques for Mature Assets

Skin Bypass Fracturing

- Small Scale Frac Treatments Designed to Produce a Conductive Path Through the Skin Damage
- Cost Effective, Easy to Perform
- More Suitable for Medium and High Permeability Formations
  - Higher *k* formations tend to have greater skin factors and so get more benefit from bypassing skin damage

20 of 39

Skin Bypass Fracturing

- Production Increase Based on Reducing Skin Factor to Zero or Slightly Lower
  - Will not produce as much stimulation as "full scale" treatment.
  - Better stimulation than matrix acid treatment
- Treatments can be Performed by Cement Units

21 of 39

Case Study #3

- South Texas
  - Gas well
  - Permeability 0.1 md
- Skin Bypass Frac Treatment
  - 14,000 lbs 20/40 Low Density Ceramic
  - 9.6 bpm maximum rate
  - VES fluid system

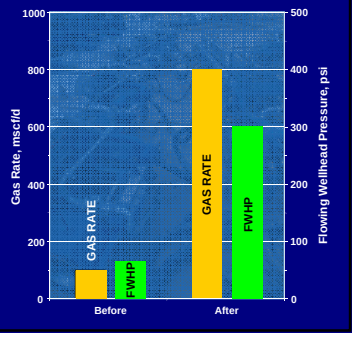
(VES = Viscoelastic Surfactant)

22 of 39

Case Study #3

From SPE 56473

- Gas Production
  - From 100 mscfd
  - To 800 mscfd
- Flowing Wellhead Pressure
  - From 70 psi
  - To 300 psi



23 of 39

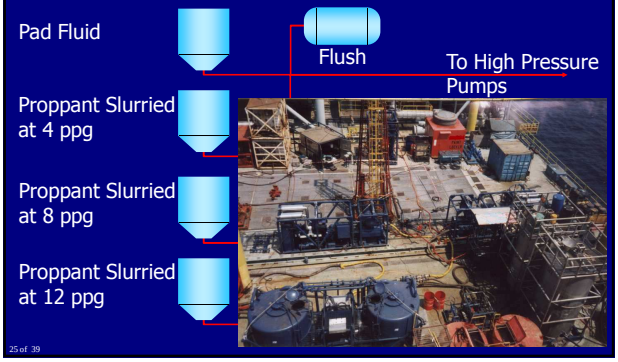
Batch Fracturing

- Eliminates the Need for Complex Blending Equipment
- Proppant is Pre-Slurried in Batch Tanks
  - All QC performed before going downhole
- Gel Type and Quality Critical

(QC = Quality Control)

24 of 39

Batch Fracturing



25 of 39

Proppant Partial Monolayer

Darin and Huitt (SPE 1291)

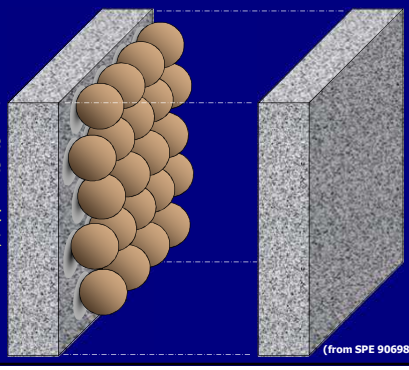
- Very Low Concentration of Proppant Produces Same Effects as Higher Concentrations
  - 0.09 lbs/ft^2 gives the same frac conductivity as +/- 4 lbs/ft^2.
  - Applicable for lower permeability formations
  - Low closure stress formations only

26 of 39

Proppant Partial Monolayer

Full Monolayer

A complete coverage of the fracture face, one proppant grain thick



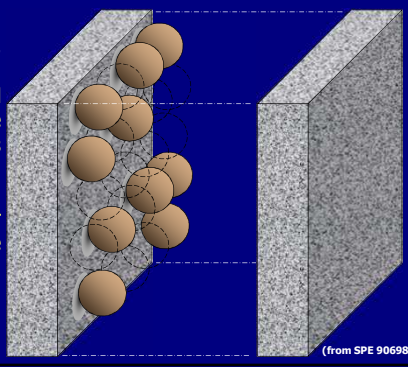
(from SPE 90698)

27 of 39

Proppant Partial Monolayer

Partial Monolayer

Increased permeability due to spaces between proppant grains. Mono-Layer keeps the same fracture width



(from SPE 90698)

28 of 39

Neutral Density Proppant

- Neutral Density Proppant does not Require Viscosity to keep it Suspended in the Fracturing Fluid
  - Fluid Costs Dramatically Reduced
- Proppant Can be Batch Mixed into Fluid Prior to Treatment
  - Sophisticated Blending and Metering Equipment not Required

29 of 39

Neutral Density Proppant

Proppant Type	Specific Gravity
Neutral Density	1.08 – 1.25
Resin-Coated Sand	2.45 – 2.55
Frac Sand	2.65
Low Density Ceramic	2.71
High Density Ceramic	3.27
Sintered Bauxite	3.55

30 of 39

Water Conformance Fracturing

- Hydraulic Fracture Treatments Performed with Relative Permeability Modifier (RPM) as part of the Treatment Fluid
  - RPM works by affecting the wettability of the formation grains
  - RPM makes it harder for water and easier for oil to flow
  - Effective in gas formations as well
  - Medium to high permeability only

31 of 39

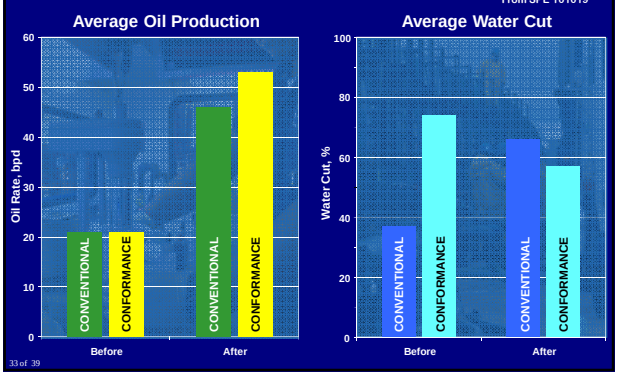
Case Study #4

- High Water Cut Mature Oil Field
  - South Sumatra, Indonesia
  - 5 Water Conformance Fractures
  - 3 Offset Conventional Fractures

32 of 39

Case Study #4

From SPE 101019



33 of 39

Refracturing

- Don't Ignore a Field because the Wells Have Already Been Fractured
  - Refracturing is a highly successful and established technique
- By Definition, it is Always Used on Mature Assets
  - Reservoir depletion is necessary to re-orient fracture
- Updated Technology

34 of 39

Case Study #5

- Tight Gas Refracturing
  - Frontier Formation, Wyoming, USA

35 of 39

Case Study #5

36 of 39

Summary of Techniques

- Skin Bypass Fracturing
- Batch Fracturing
- Proppant Partial Monolayer
- Neutral Density Proppant
- Water Conformance Fracturing
- Refracturing

Techniques Can Be Combined!

37 of 39

Mature Field Redevelopment with Hydraulic Fracturing

- Understand the Reservoir First
  - Permeability, reservoir pressure, reserves, fracture azimuth
- Get Value for Money
  - Appropriate technology
  - Economies of scale
  - Avoid false economies

38 of 39

Thank You

Any Questions?

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- Link on left side above “Chat box”

40