Completion and production

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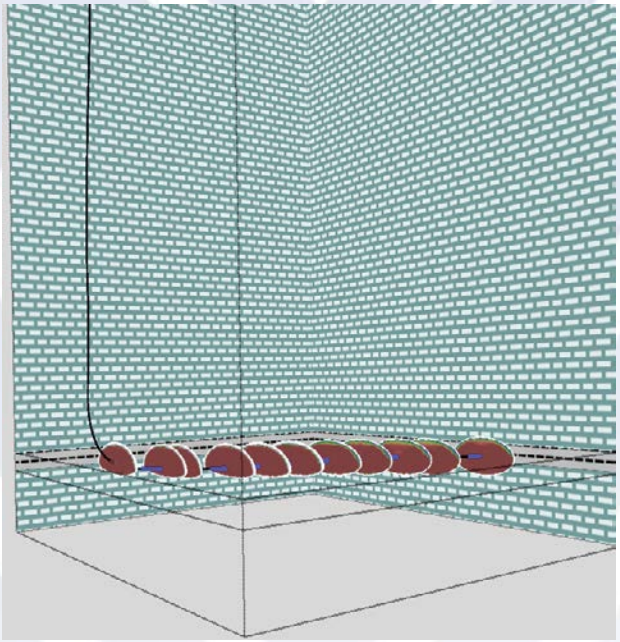
Outline

- Introduction to hydraulic fracturing
- Productivity enhancement using hydraulic fracturing
- Fracture dimension and direction
- Fracturing materials
- Fracturing diagnostic technologies

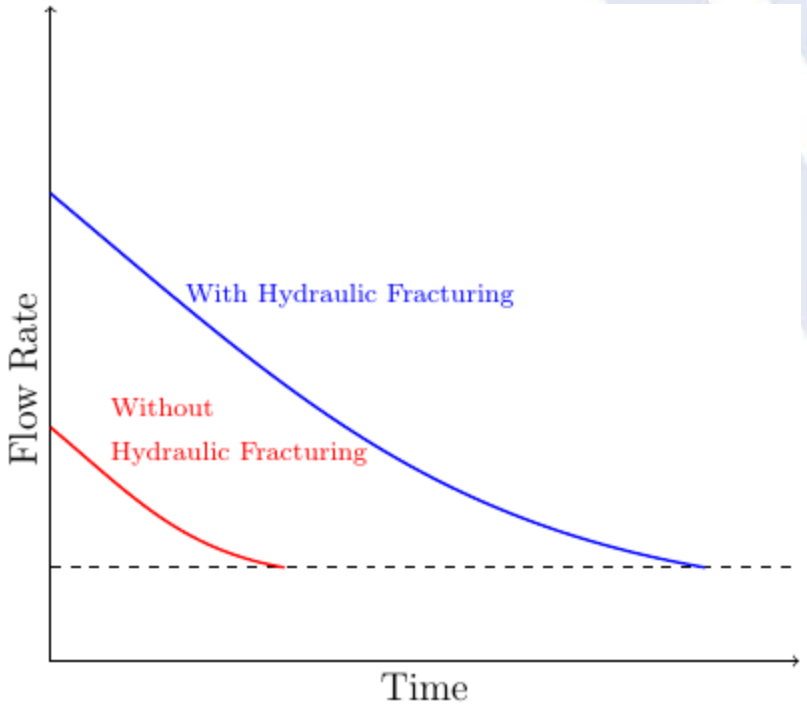
What is hydraulic fracturing?

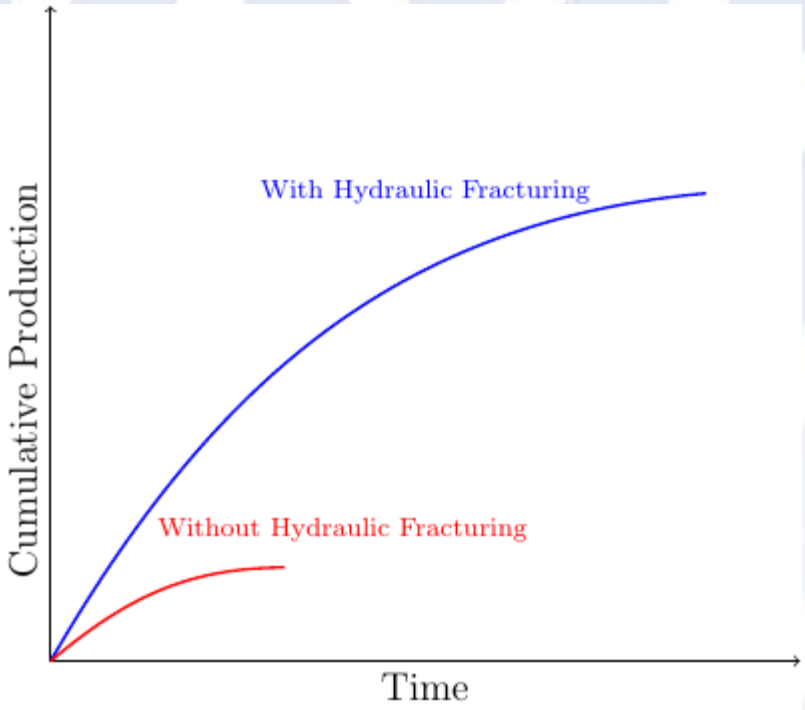
Hydraulic fracturing is a well stimulation technique in which high pressure fluids are injected to fracture the rock.



Why Hydraulic fracturing?

Production enhancement because of hydraulic fracturing



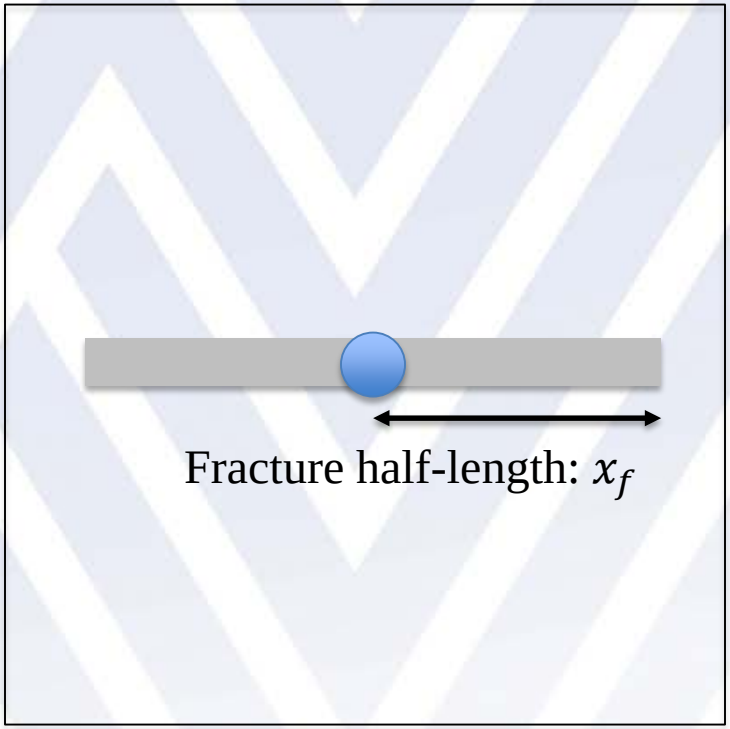


http://petrowiki.org/PEH

Dimensionless fracture conductivity: a key design parameter

- Dimensionless fracture conductivity:

$$C_{fD} = \frac{k_f w}{k x_f}$$



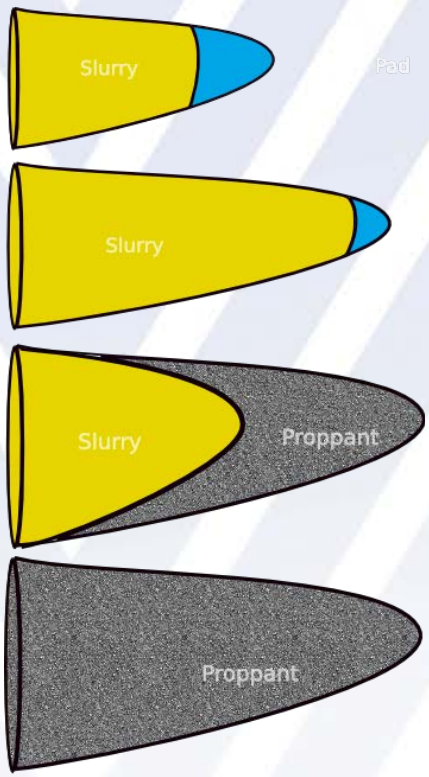
w: fracture width

k: permeability of the formation

k_f: fracture permeability

Hydraulic fracturing steps

1. **Perforation:** creation of points where fracture initiates
2. **Pad fluid injection:** pad fluid creates the fracture and controls the fluid loss.
3. **Proppant injection:** proppants are injected into the fracture to keep it open. Pad volume gradually decreases due to leak-off. Proppants become more concentrated due to fluid leak-off.
4. **Cleaning out:** displacing proppant from the casing to the surface

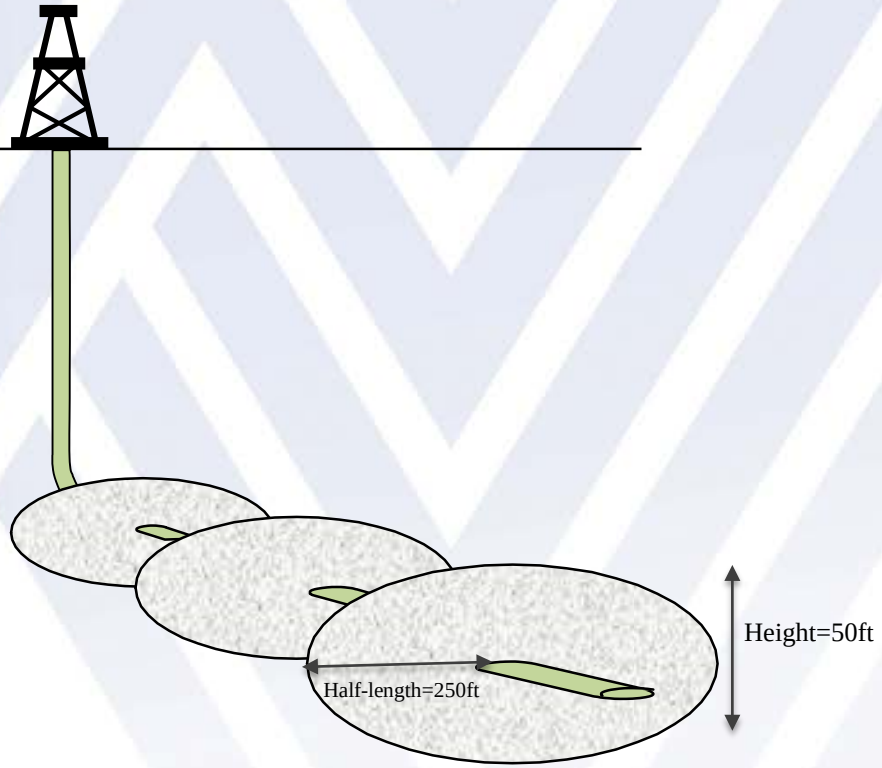


Typical operation sizes

- Proppant per stage = 200,000 to 600,000 lbs
- Water per stage = 4,000 to 9,000 barrels
- Maximum allowable pressure = 9,000 to 9,500 psi
- Flow rate = 70- 120 bpm
- Number of perforations = 28-45
- Number of clusters = 3-7
- Perforation phasing = 60 and 180
- Perforation diameter = 0.42in
- Plug-to-plug spacing= 150-500ft

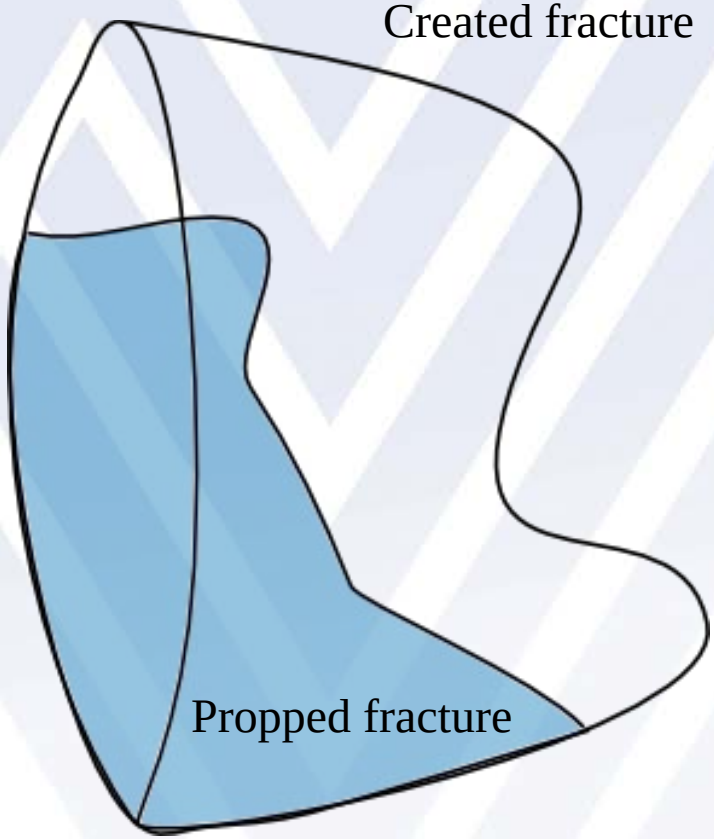
Fracture dimensions

- Contact area with the reservoir, per stage: 50,000 ft^2
- contact area for 20-stage hydraulic fracturing treatment: 1,000,000ft^2
- Area of contact is in more than size of 20 soccer fields!
- This number would be larger if we considered pre-existing complex fracture network in the formation.
- Typical fracture width is less than an inch!



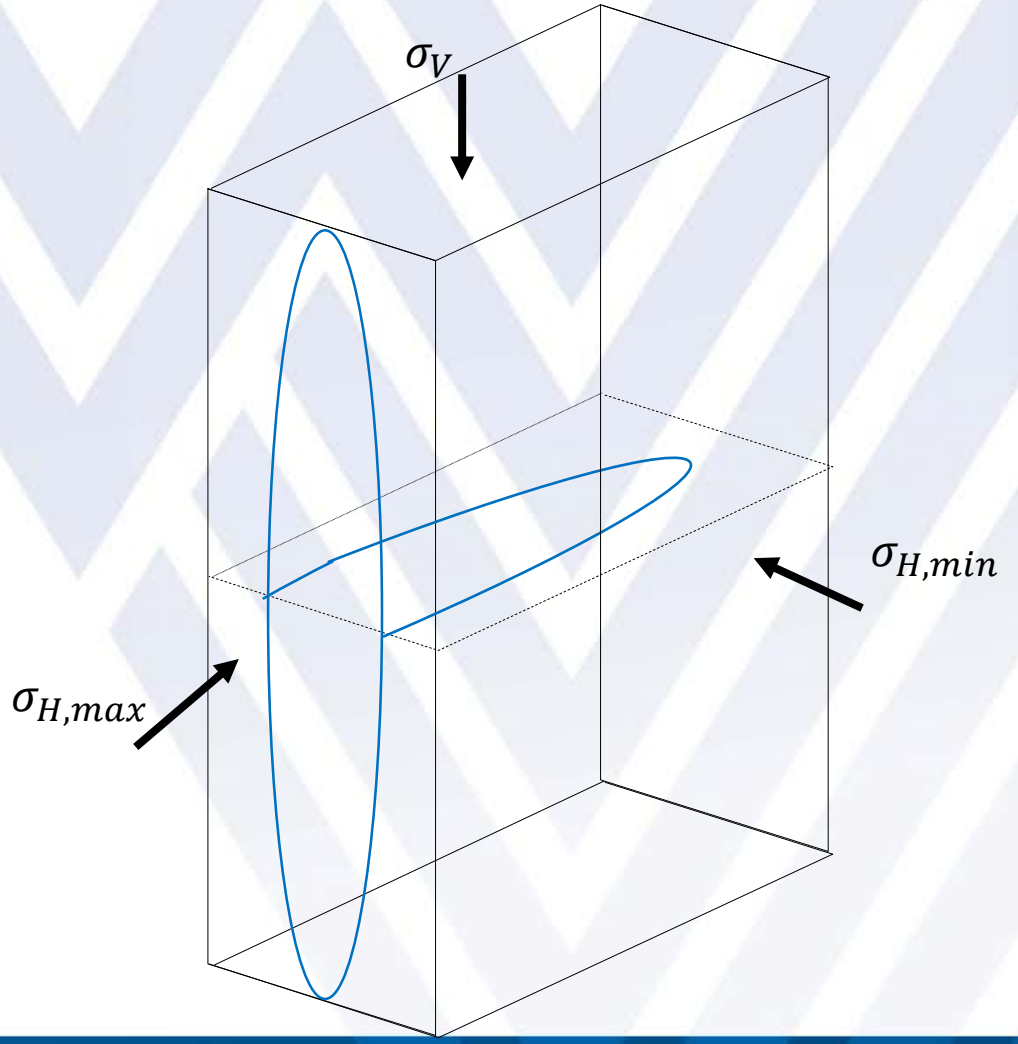
Difference between created and propped fracture dimensions

- Created fracture dimensions are different from the propped fracture dimensions. Propping agents tend to settle in the fracture as a result of gravitational forces.

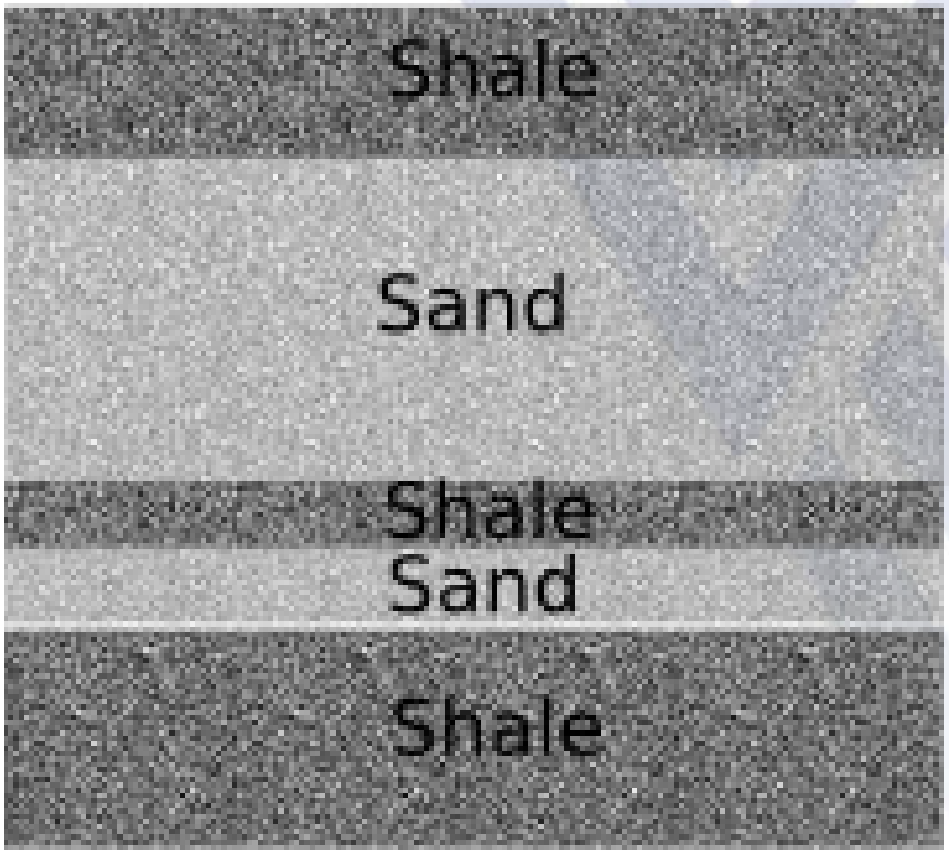


Hydraulic fracture direction

- Hydraulic fractures propagate perpendicular to the minimum stress.

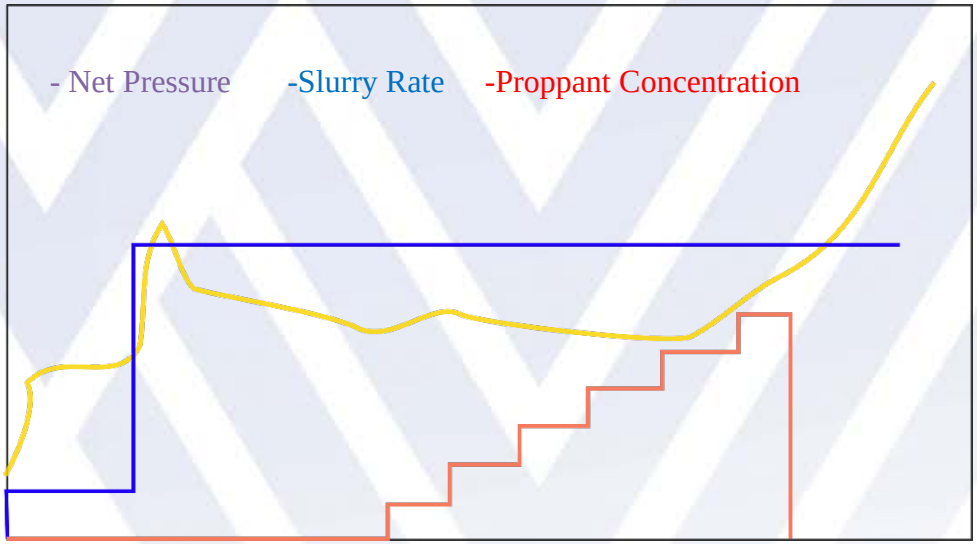


Stress profile



Typical fracture treatments

Monitoring the pressure response allows us to interpret the fracture geometry.



Fracturing materials

Fluid

- Fracturing fluids are injected to create the fracture and transport the proppants.
- Various additives are usually added to the fracturing fluids. Common fluid additives are: Crosslinkers, Breakers, Fluid-loss additives, Biocides, Stabilizers, Surfactants, Clay stabilizers

Proppant

- Propping agents are required to keep the fracture open so that a conductive path to the wellbore is retained after pumping has stopped. Most of proppants can be categorized into one of the following proppant types:
- Sand
- Ceramic proppants
- Resin-coated sands

Hydraulic fracture complexity

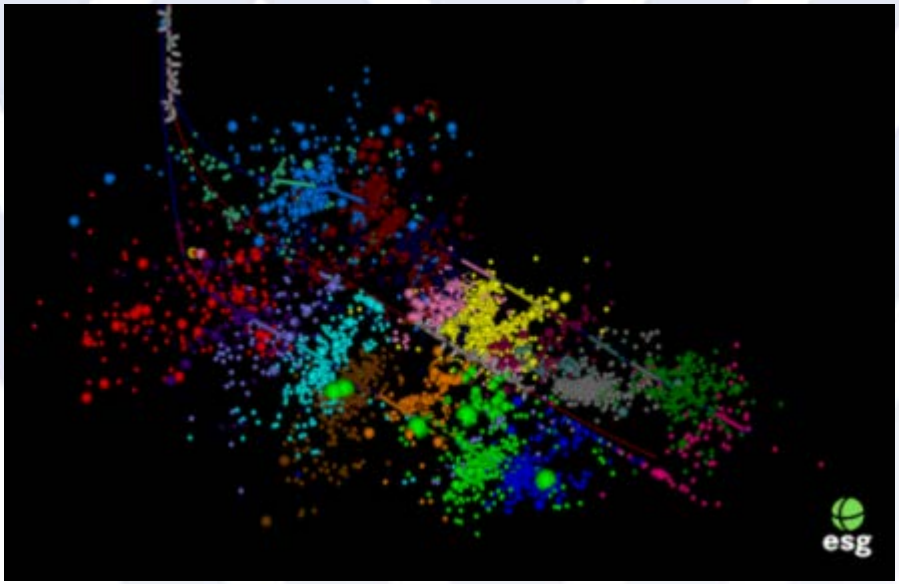
- Assumptions:
- Fractures are bi-wing and single planar
- In numerous cases, fractures are documented to be in multiple parallel planes and in multiple directions. Numerous cases are reported of incomplete coverage of pay zones, deviation from the wellbore causing connection problems, and growing into unwanted water or gas intervals.

Fracture Mapping Technologies

Fracture mapping technologies are used to evaluate whether the entire formation is being sufficiently stimulated.

Common technologies:

- Microseismic fracture mapping
- Tiltmeter fracture mapping



Microseismic mapping (Photo courtesy of ESG Solutions)