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Horizontal Well Frac Design Considerations

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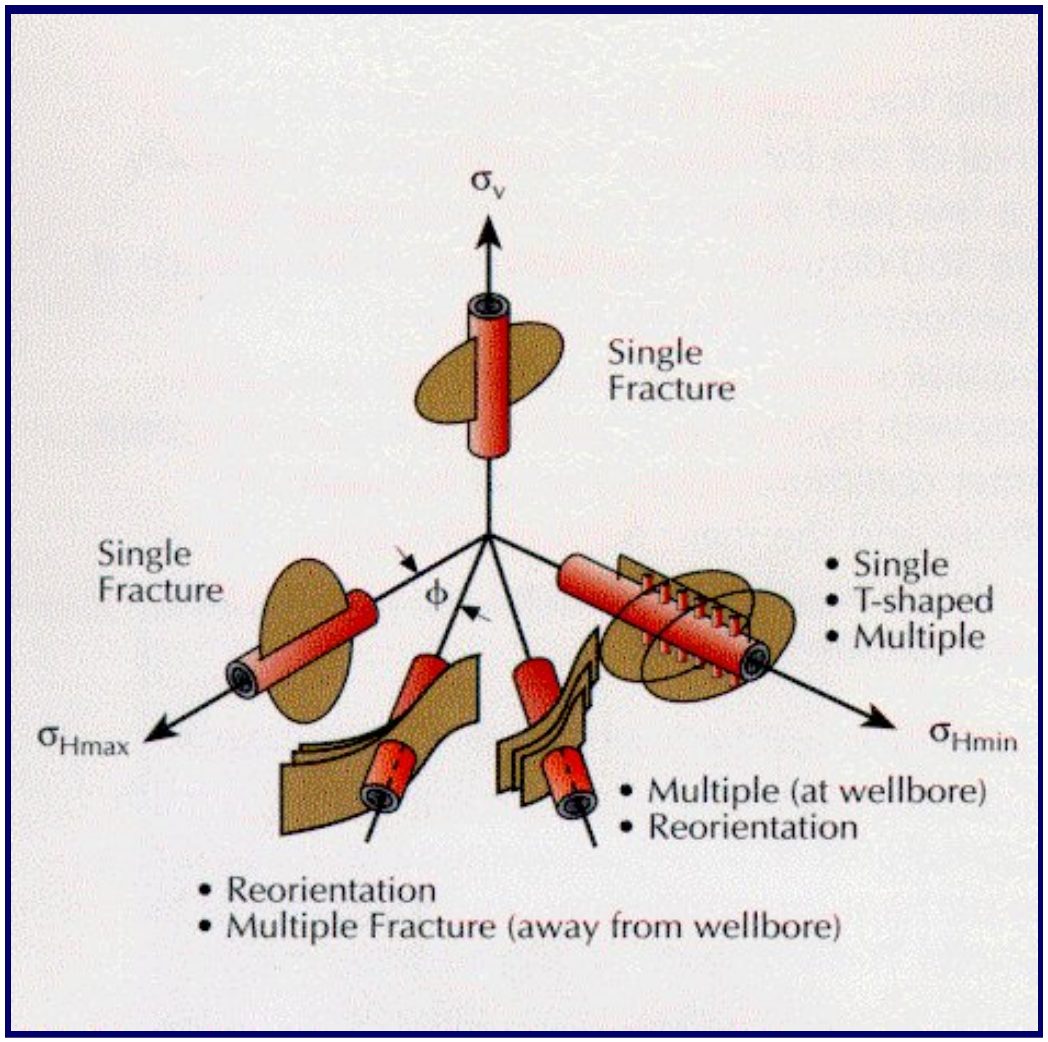
Presented By; Mike Eberhard, P.E.
Halliburton Energy Services
Denver, CO

Wellbore Considerations

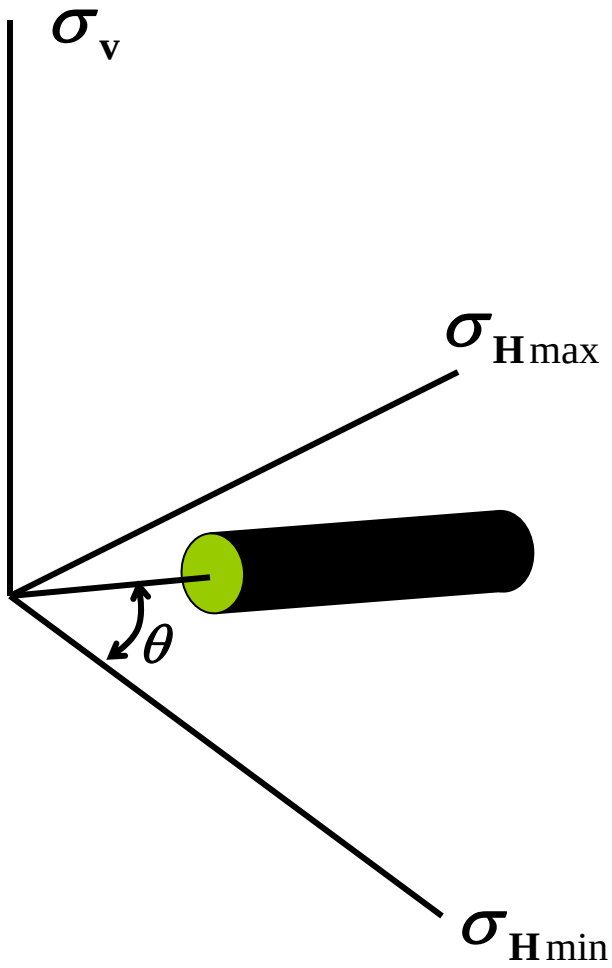
- **Considerations before the well is drilled**
  - Wellbore orientation
    - **Fracture direction, Number of fractures**
  - Wellbore configuration
    - **Open hole, Cemented liner, etc.**
  - Reservoir acid solubility
    - **Acid versus Proppant**

Fracture Geometries



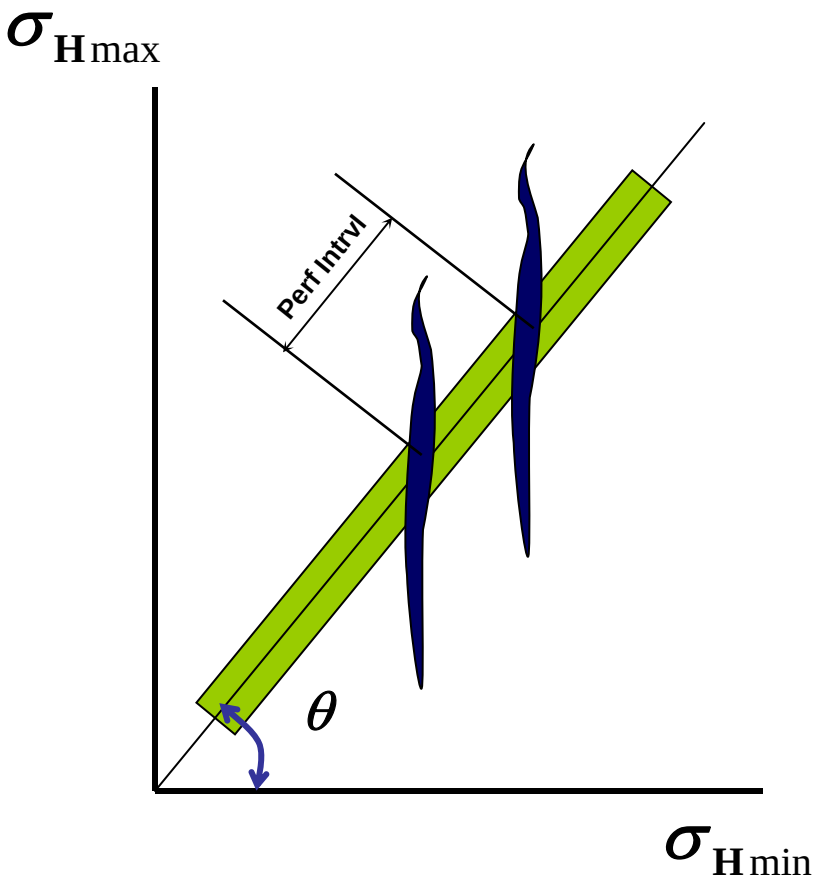
Multiple fractures can occur when the perforated interval exceeds $4r_w$ (dependent on θ)

Horizontal Wellbore Orientation



- **A horizontal wellbore is more stable than a vertical wellbore for $\theta = 0 - 50°$ from σ_{Hmin}.**
- **Breakdown Pressures**
  - Maximum @ $\theta = 0°$ from σ_{Hmin}
  - Minimum @ $\theta = 90°$ from σ_{Hmin}
    - **Breakdown pressures can be several thousand psi lower**
- **As σ_v decreases breakdown pressures increase.**

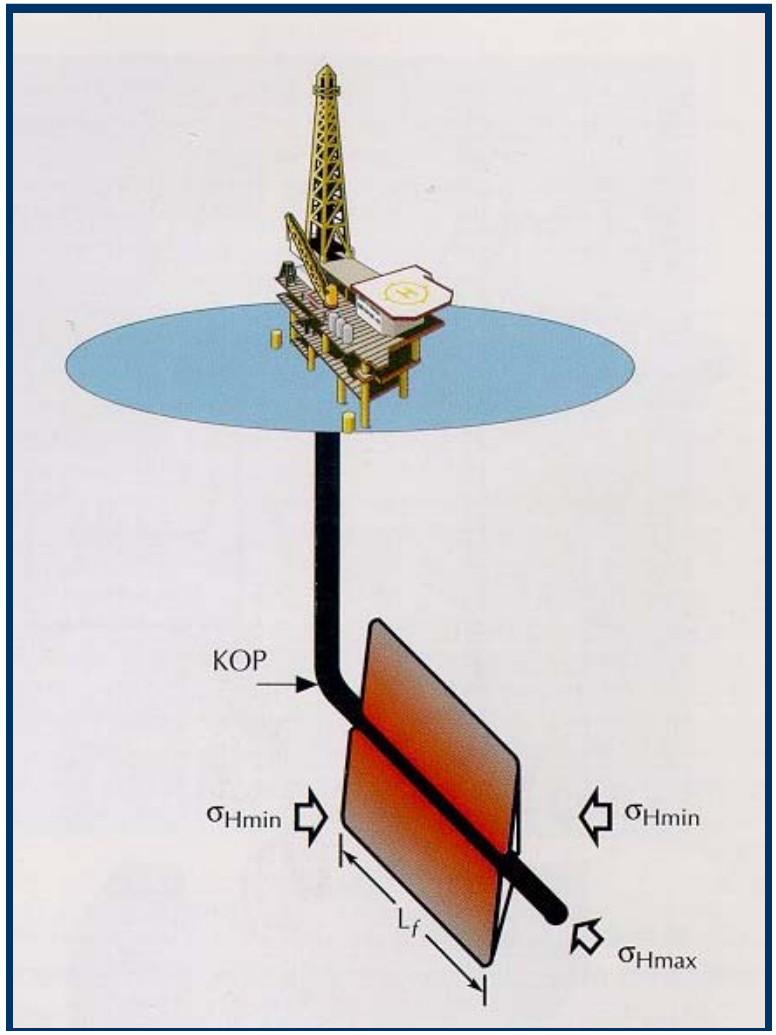
Calculation of Perforation Interval



The following equation calculates the maximum perforated interval to avoid multiple fracture in a deviated wellbore

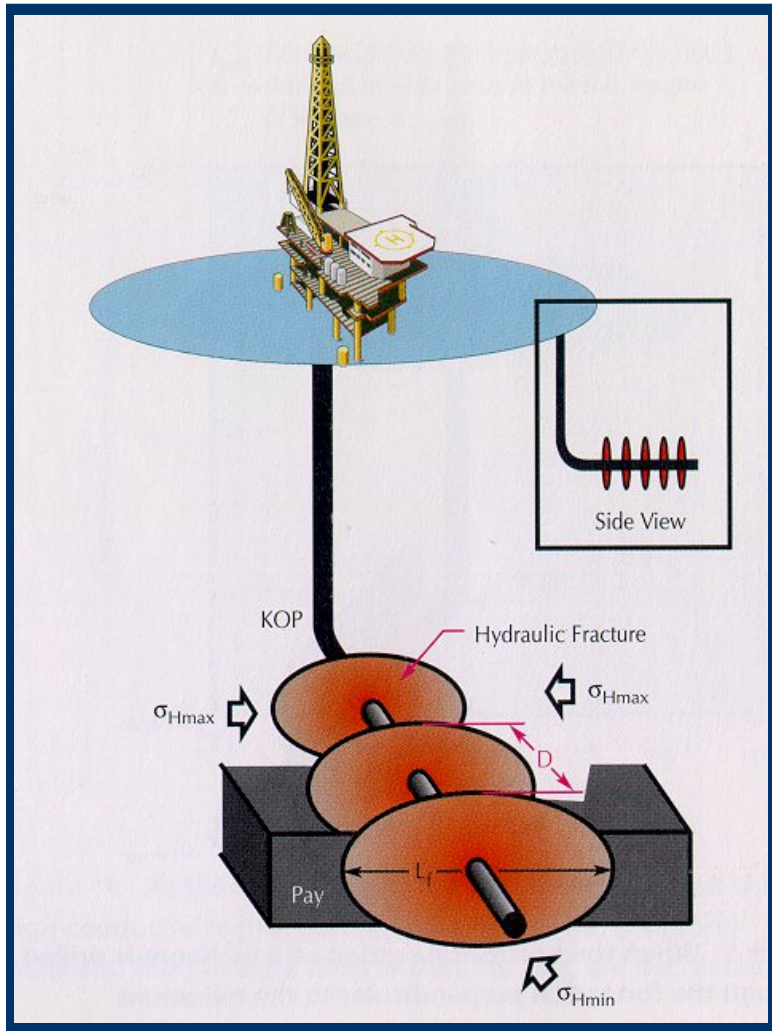
$$\text{Perf Intrvl} = \frac{4r_w}{\text{Sin}\,\theta}$$

Longitudinal Fractures



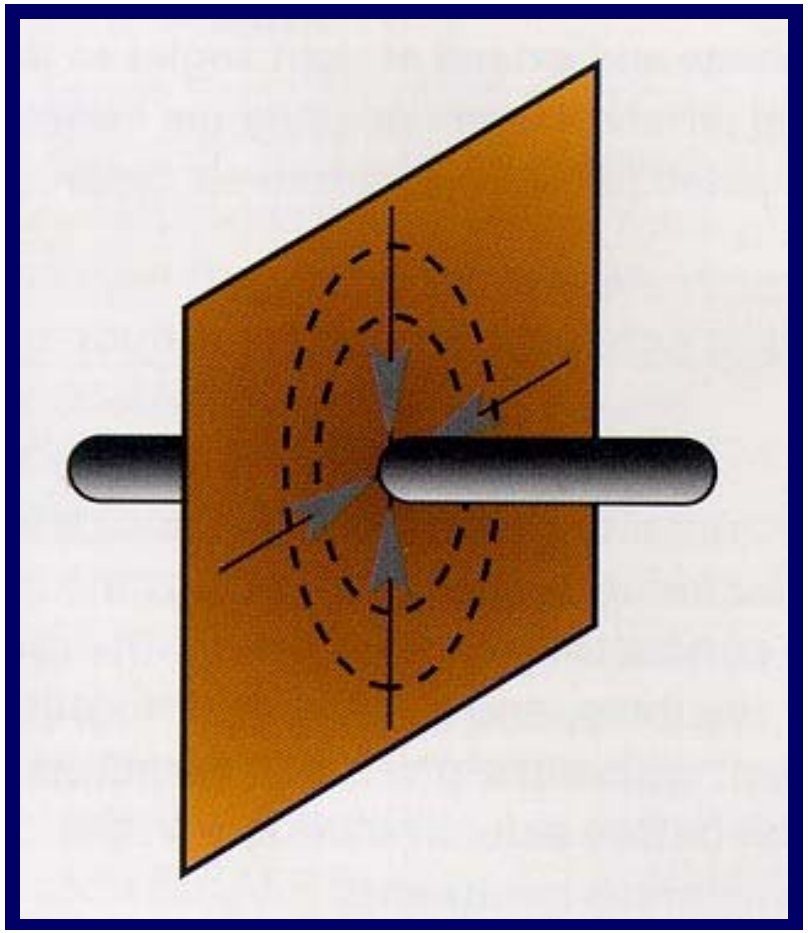
- Occur when $\theta = 90°$ from σ_{Hmin}
- Fractures initiate along the wellbore when the wellbore is within 10° of σ_{Hmax}
- Resembles fracturing vertical wells
- Can be open hole, perforated liner, or cemented casing
- Length of induced fracture is determined by injection rate

Transverse Fractures



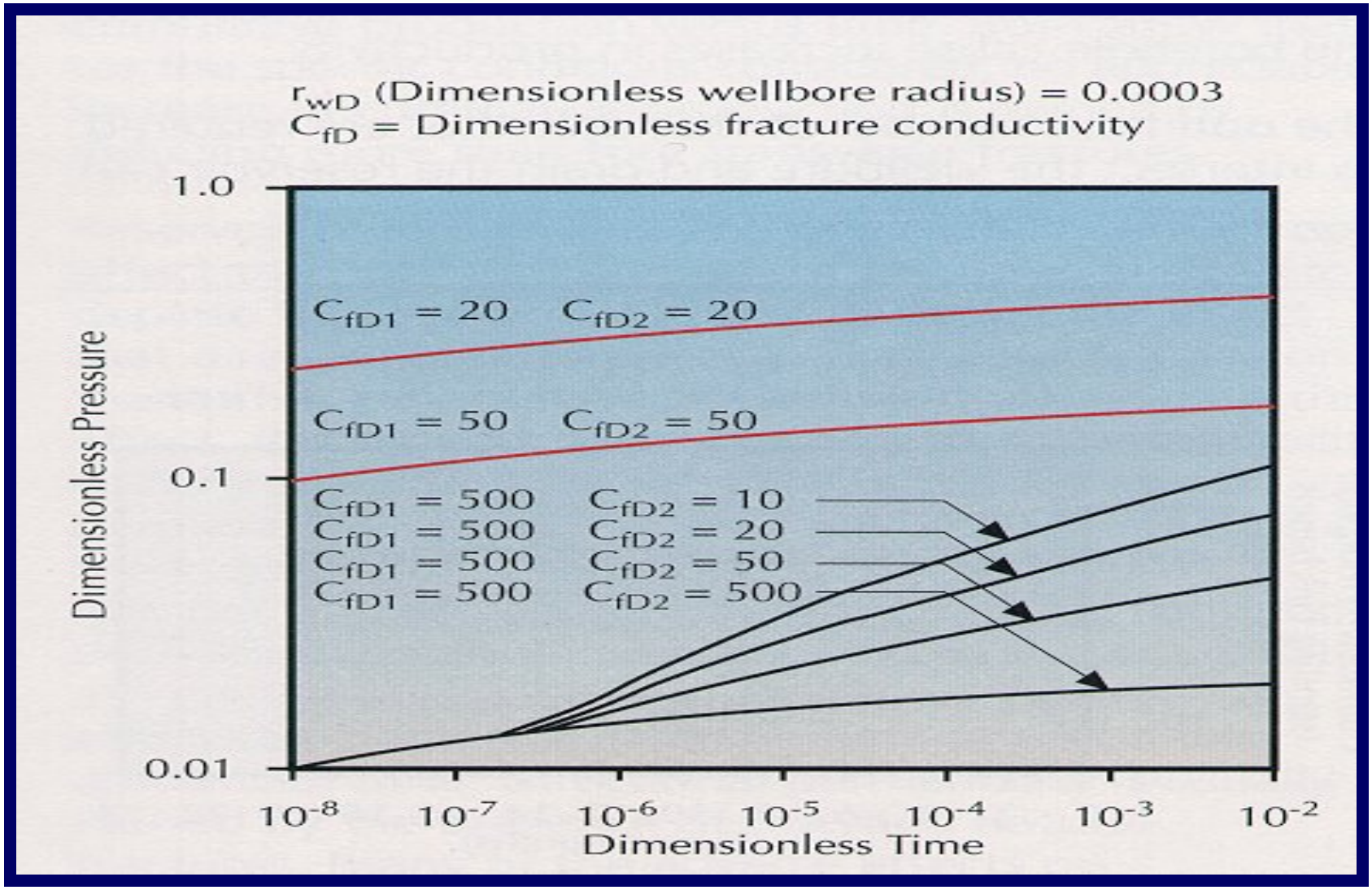
- Occur when $\theta = 0°$ from σ_{Hmin}
- Fractures grow perpendicular to the wellbore
- Can require cemented casing for fracture isolation
- Fracture spacing is dependent on reservoir
- High fracture conductivity is required near wellbore to allow cleanup

Radial Convergence

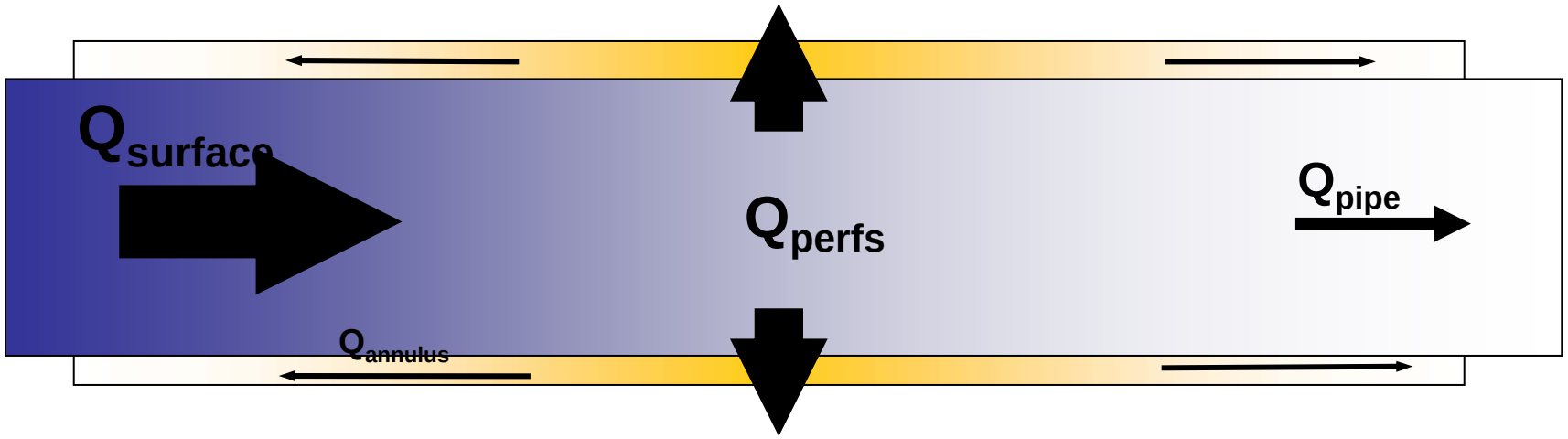


- **Fluids radially converge in a transverse fracture approaching a horizontal borehole.**
  - High pressure drop
  - High fracture conductivity is essential

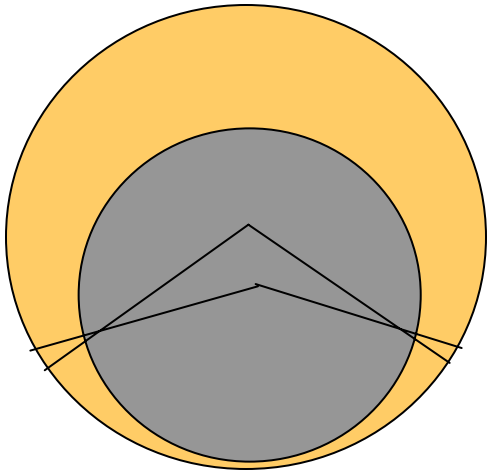
Convergence Pressure Drop



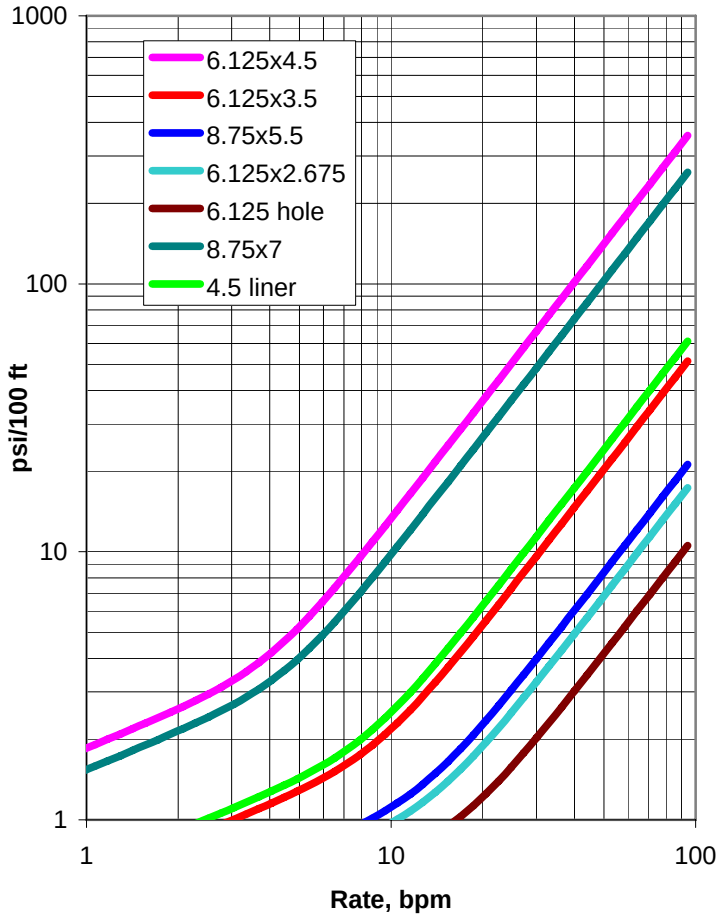
Annular Pressure Drops



Annular Pressure Drop - Uncemented Liners



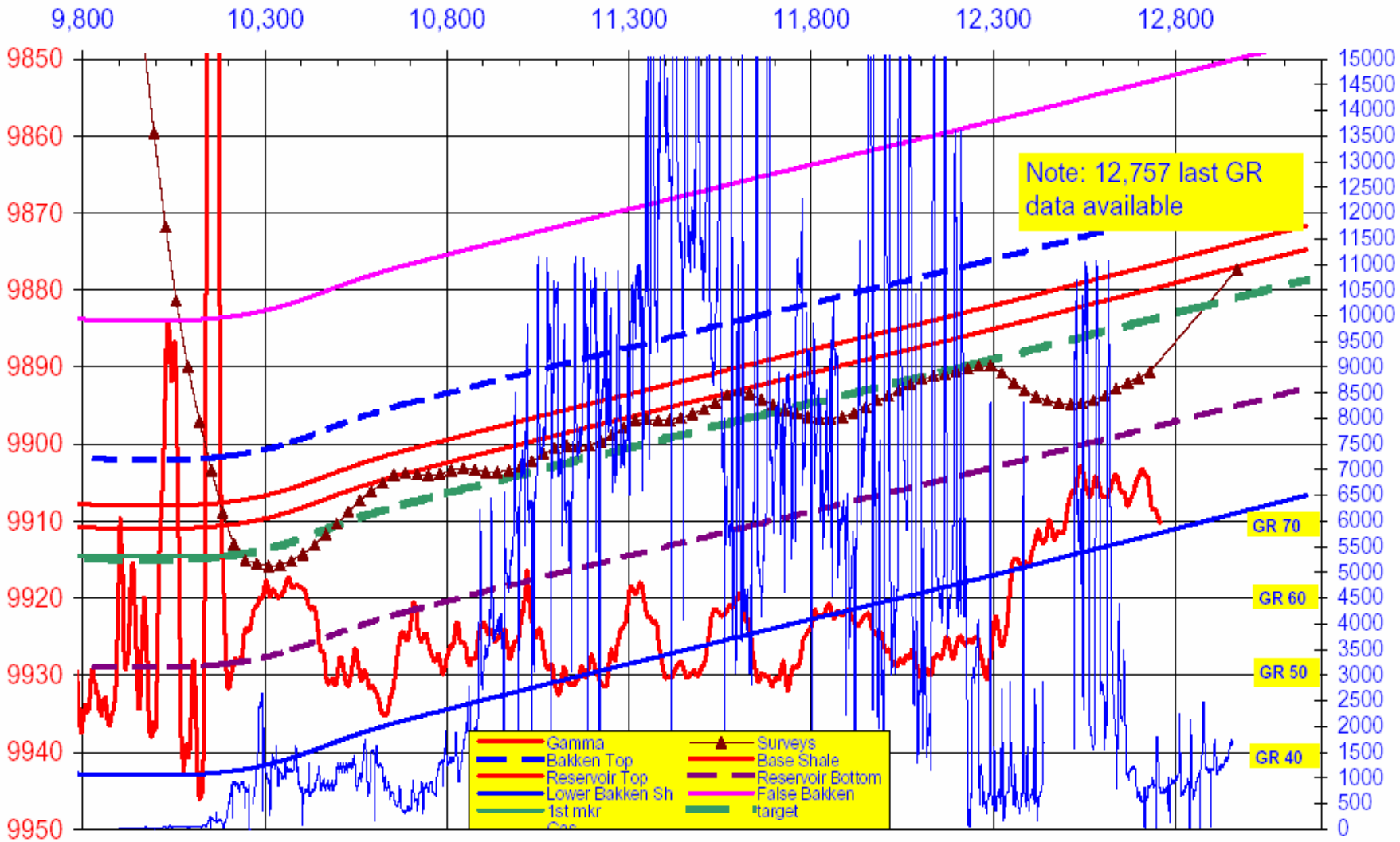
$$HydDia = \frac{\left(OD_h^2 - OD_l^2\right)}{\left(0.66OD_h + 0.58OD_l\right)}$$



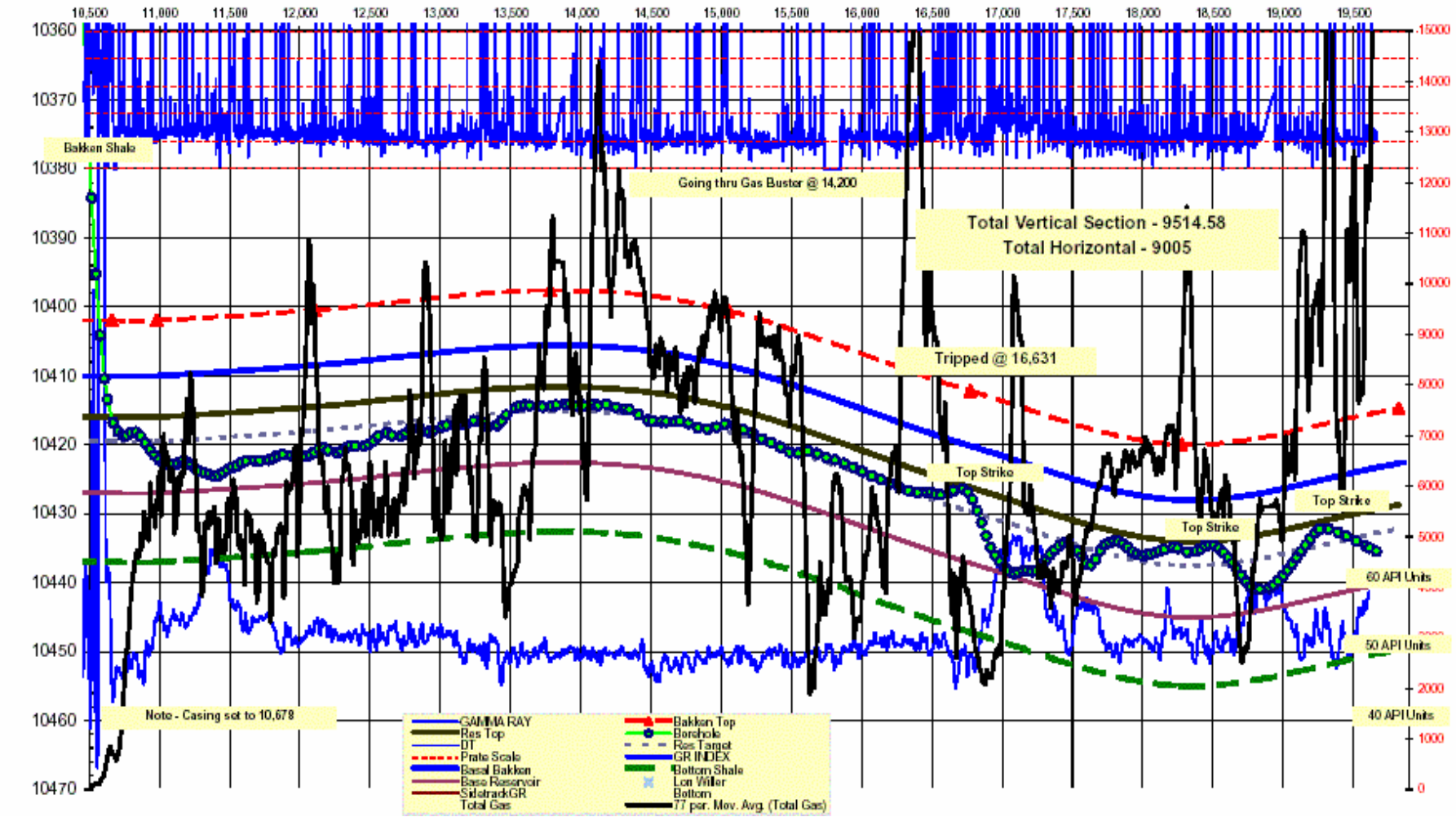
Fracture Design

- **What do we need to consider?**
  - Formation properties along the lateral
    - **Changes in k, P_p, etc**
  - Rock properties along lateral
    - **Changes in E, ν, σ, etc**
  - Fracture orientation
    - **Stress anisotropy**
  - Reservoir acid solubility
  - Variation in stresses above and below target formation
  - Fracture conductivity requirements
  - Mechanical placement controls

Bakken Horizontal

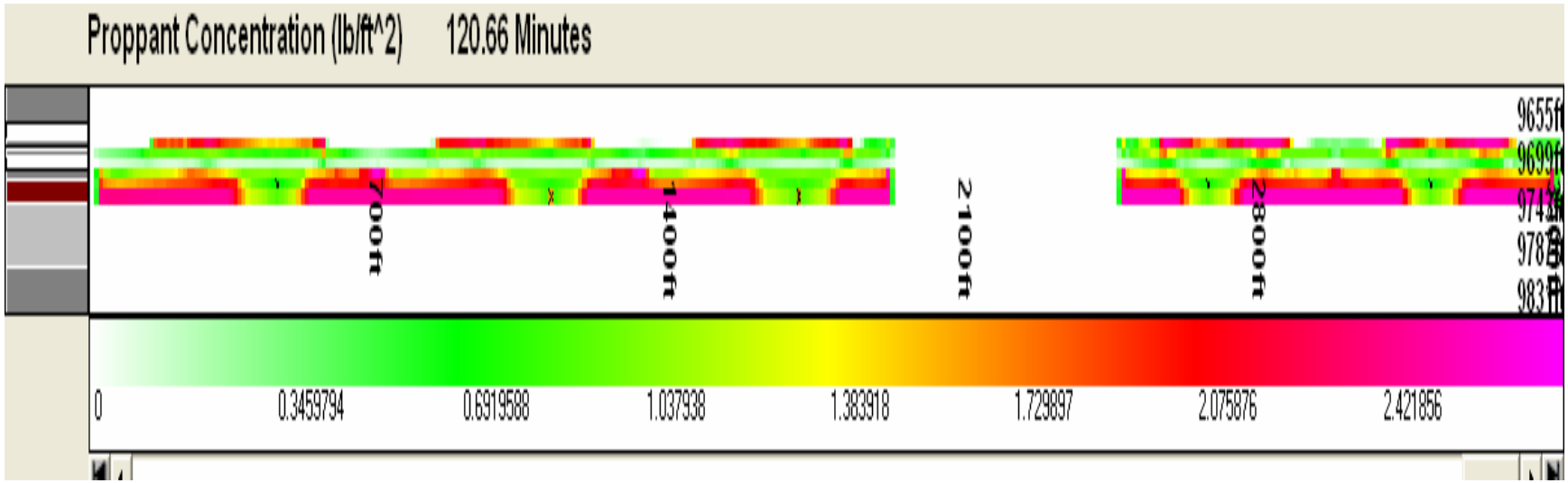


Bakken Horizontal 2

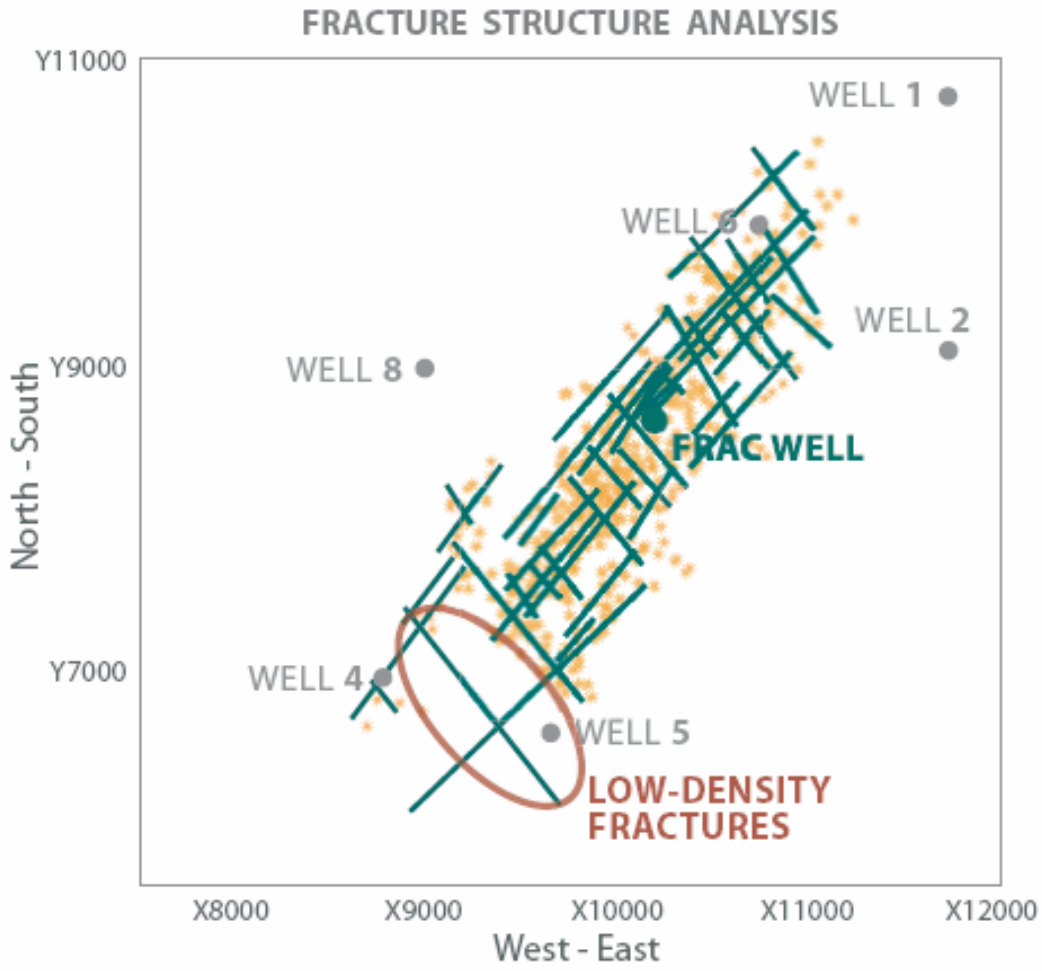


Fracture Models

- **GOHFER will allow for vertical and lateral variations in reservoir/rock properties.**
  - You need the data to put in…
  - Will model longitudinal fracture growth but will not predict transverse components.

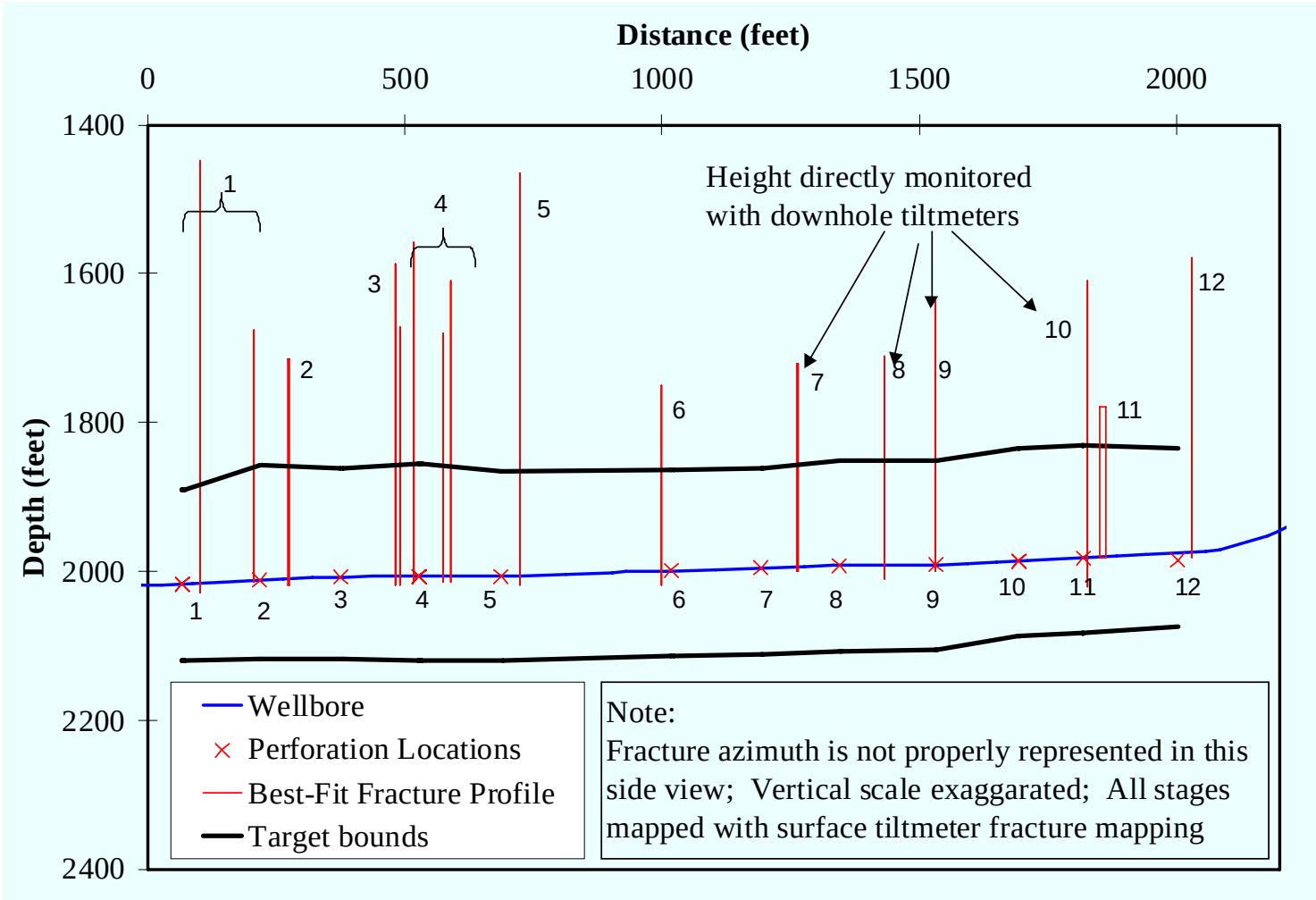


Example of Complex Fracturing



Source: Pinnacle Technologies – Advance it Down the Fairway

Example of Propped Fractures



Source: Pinnacle Technologies - From SPE 38632

Bakken Designs

- **Variety of wellbore orientations**
  - Multi-lateral open hole completions
    - **Frac one or all laterals at once**
    - **Utilize high rate for diversion**
  - Uncemented liners
    - **Diverter stages and balls**
    - **Packer systems**
- **Primarily large volumes of 20/40 sand**
  - Others – ISPs, 100 mesh, 30/50 and 40/70
- **Primarily crosslinked gel systems**
  - Water fracs are being pumped

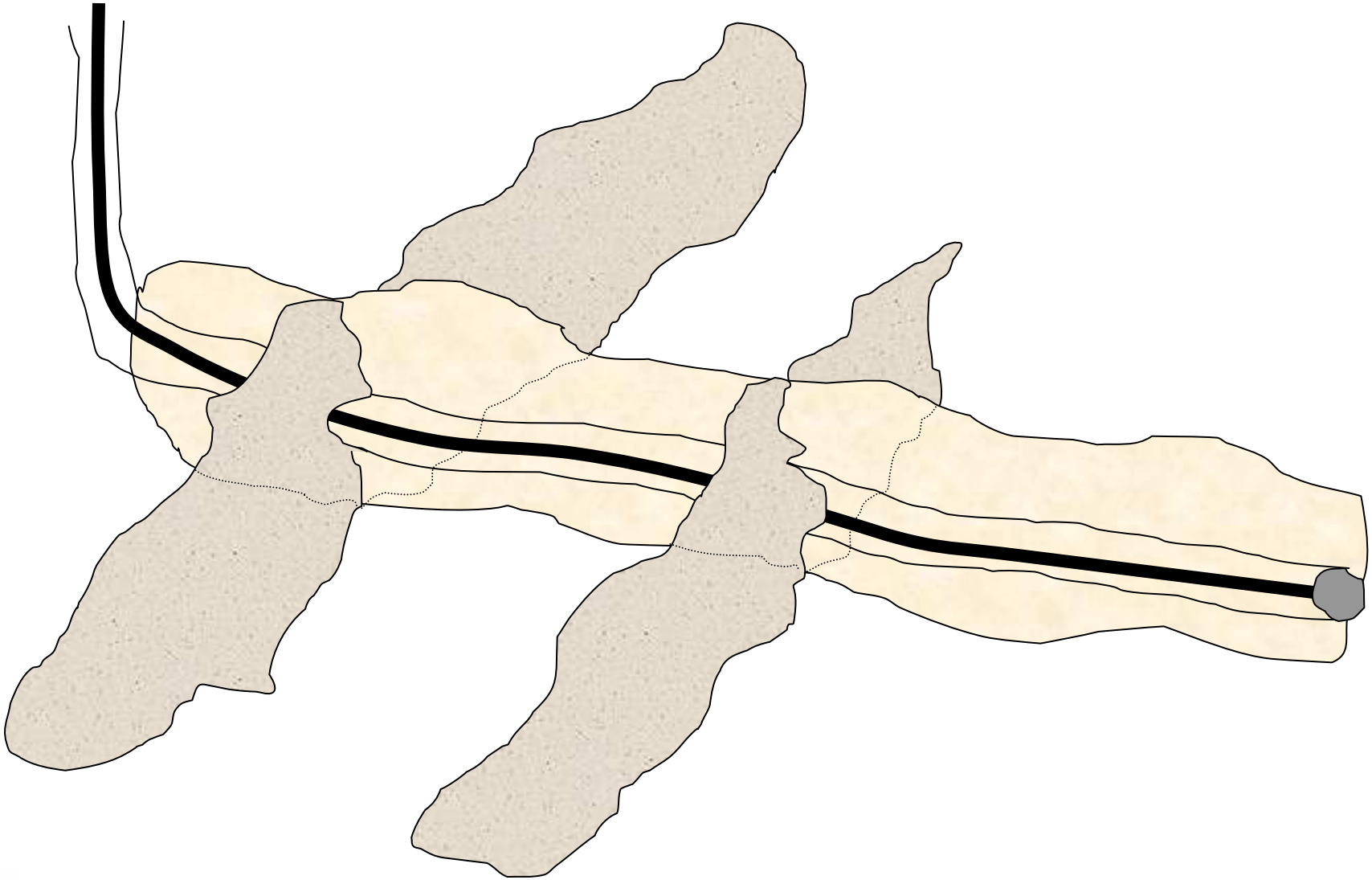
What Do We Know?

- **Tracers indicate longitudinal coverage in uncemented liner wellbores.**
- **Transverse fracturing indicated by E/W wellbore frac communication**
  - No significant stress anisotropy
- **More lateral length makes better wells**
  - However shorter laterals produce better /ft of lateral

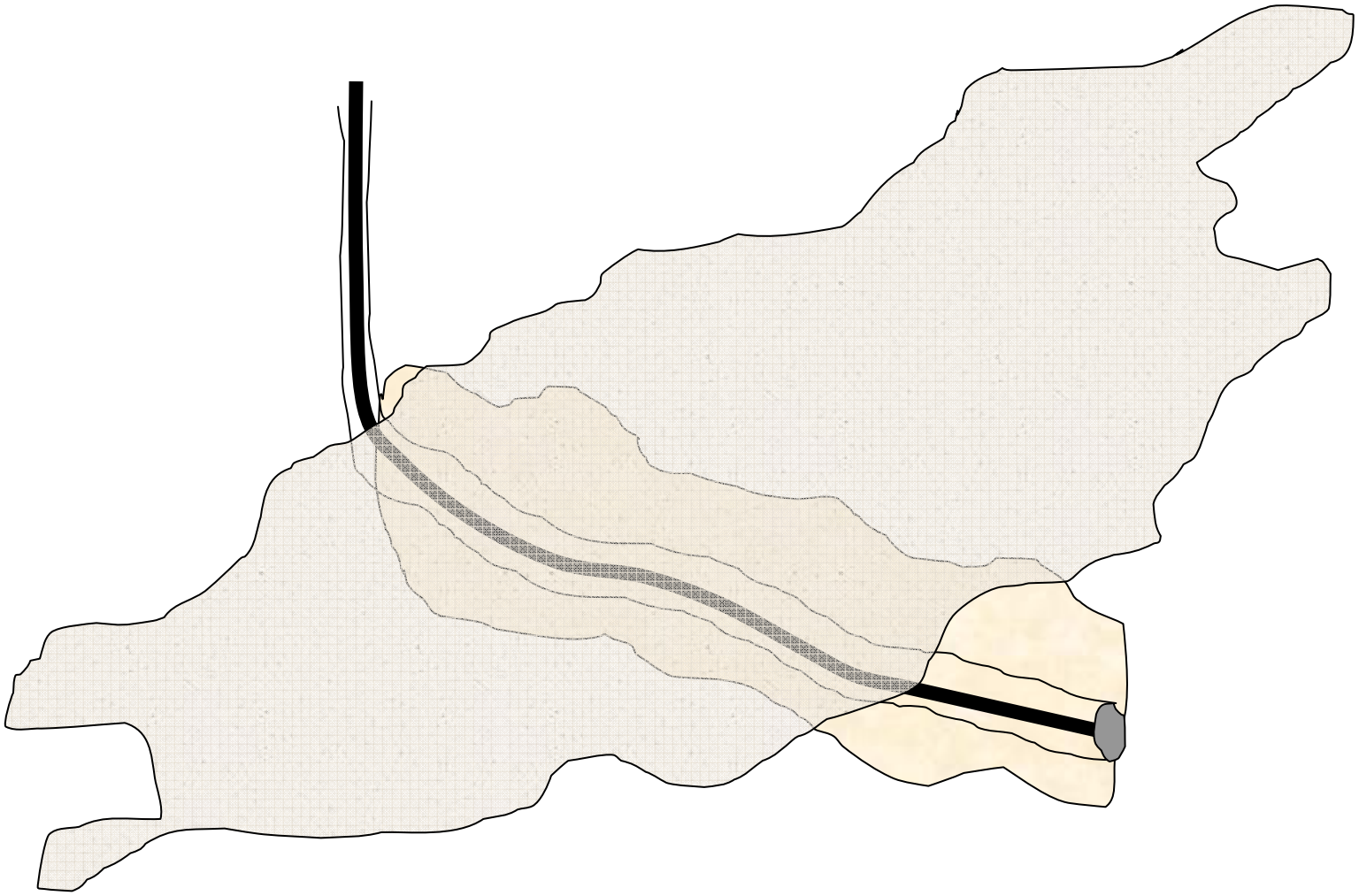
What Don't We Know??

- **Transverse fracture component**
  - When they initiate or how many
  - Their contribution to production
- **Optimum proppant/fluid volume**
  - Are transverse fractures a function of large treatment volumes or rate?
- **What, if anything, should be done different on the ND side**
  - Same name different rock

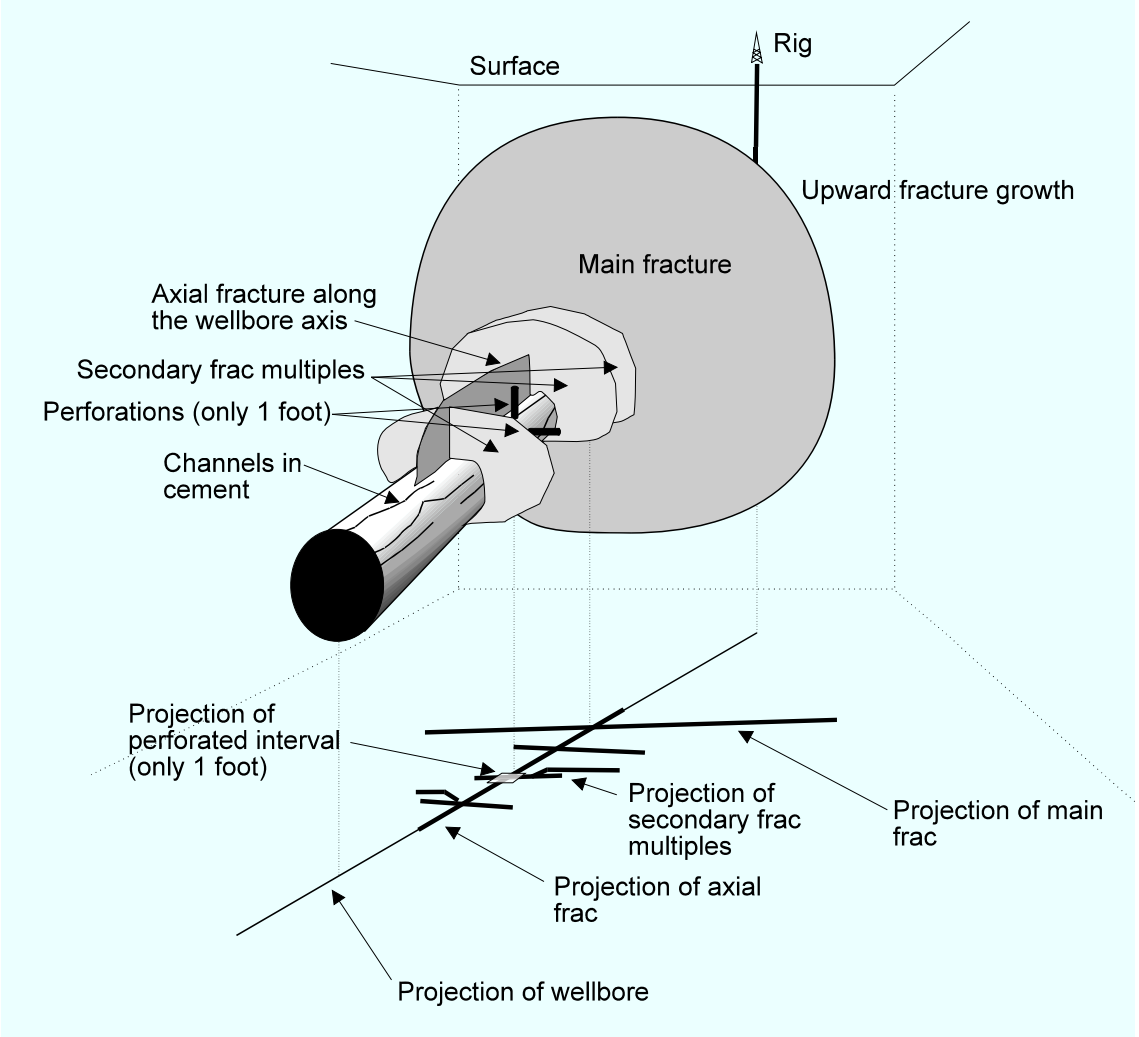
Bakken???



Or



And You Thought It Was Easy



Source: Pinnacle Technologies - From SPE 38632

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Thank You