[AV]The Geologist and the Engineer, In Need of Each Other More Than Ever*

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Abstract

Historically, earth scientists ponder maps, logs and other data in search of prospective hydrocarbon traps. A map with a carefully placed location would be provided to the engineering group. The well was then designed and drilled. The groups would exchange information to insure the target was hit in an optimal position and, if successful, completed in the target formation. Logs were run to estimate potential reserves, and to verify additional drilling opportunities. Although oversimplified, this was often the limit of communication between the rock focused earth scientist and the math focused engineer.

However, this is no longer the case in the age of unconventional gas exploitation. While the basic needs for geologic analysis remain unchanged there is a significant increase in the need for communication and coordination between these two disciplines.

No longer relegated to placing a dot on a map and waiting to see if the engineer finds the target trapped, sourced and sealed as envisioned. Now the geologist's work continues, and in more detail than before. Rock mechanics, mineralogy, clay content, secondary mineralization, Young's Modulus and Poisson's Ration, nano-darcy and pico-darcy have become every day terminology that all disciplines must work to understand for their well planning and completions.

Communication between these groups is essential to promote innovation and optimization in these technologically challenging unconventional plays. And both are necessary for success.

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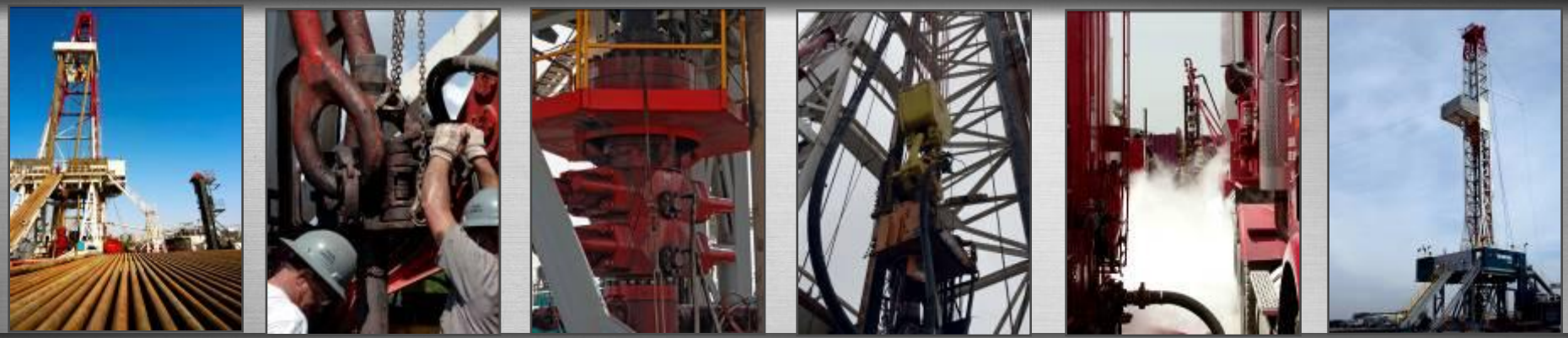

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The geologist's role?

- Look at dry holes in an area
- Draw a high between them
- Wait for engineers to drill another well

The engineer's role?

- Grumble about the geologists drawing another map between dry holes

- Drill a well to the geologist's target zone

Engineers steer the well to the target

The engineer's role?

- Grumble about the geologists drawing another map between dry holes
- Drill a well they "know" will likely be dry
- Stay below AFE costs to "look good" drilling the dry hole
- Wait for geologists to draw another map

Their NEW roles in Resource Plays

- Geoscientists
  - Locate potential resource
  - Map major structural issues
  - Research geochemical properties of the resource rock
  - Collaborate with engineers to predict resource potential

Their NEW roles in Resource Plays

- Engineers
  - Estimate resource volume – (H x L x W)
  - Mechanical properties of the rock
  - Collaborate with geologists to predict resource potential

Their NEW roles in Resource Plays

- Engineers and Geologists together
  - Obtain project approvals
  - Plan initial testing strategies to gather data
    - 2D or 3D seismic program
    - Geochemistry data
    - Rock mechanics data
    - Testing procedures
    - Logging procedures
    - Micro-seismic program

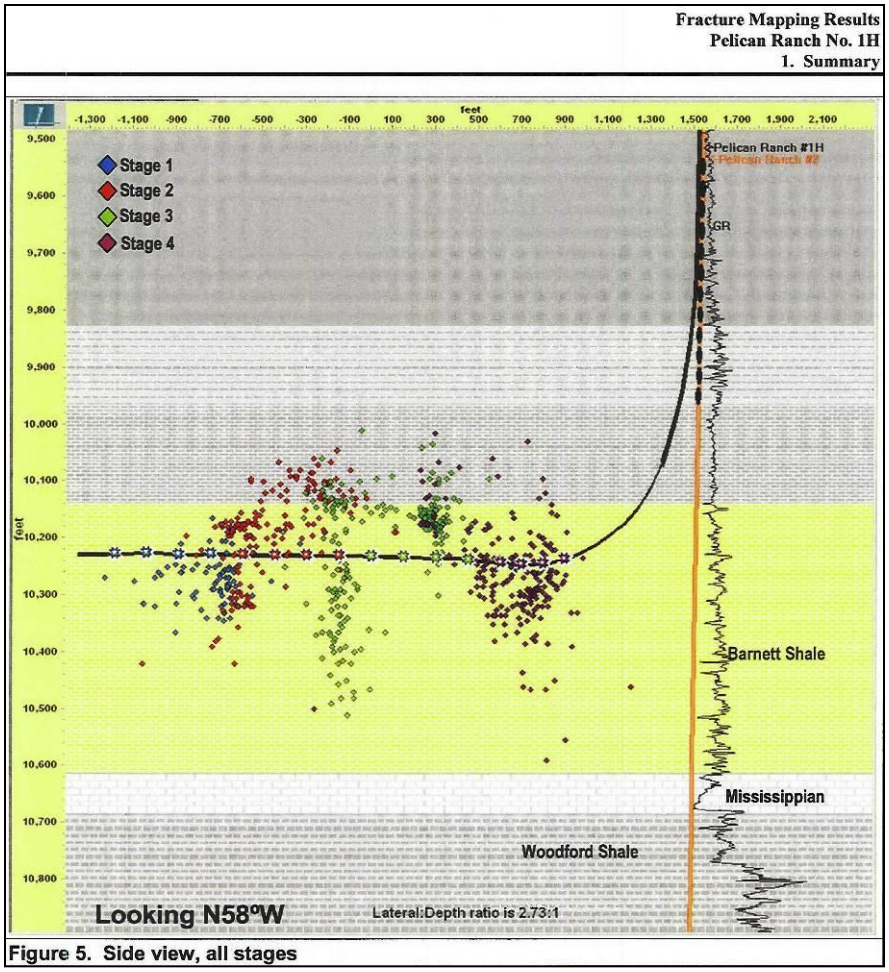


Figure 5. Side view, all stages

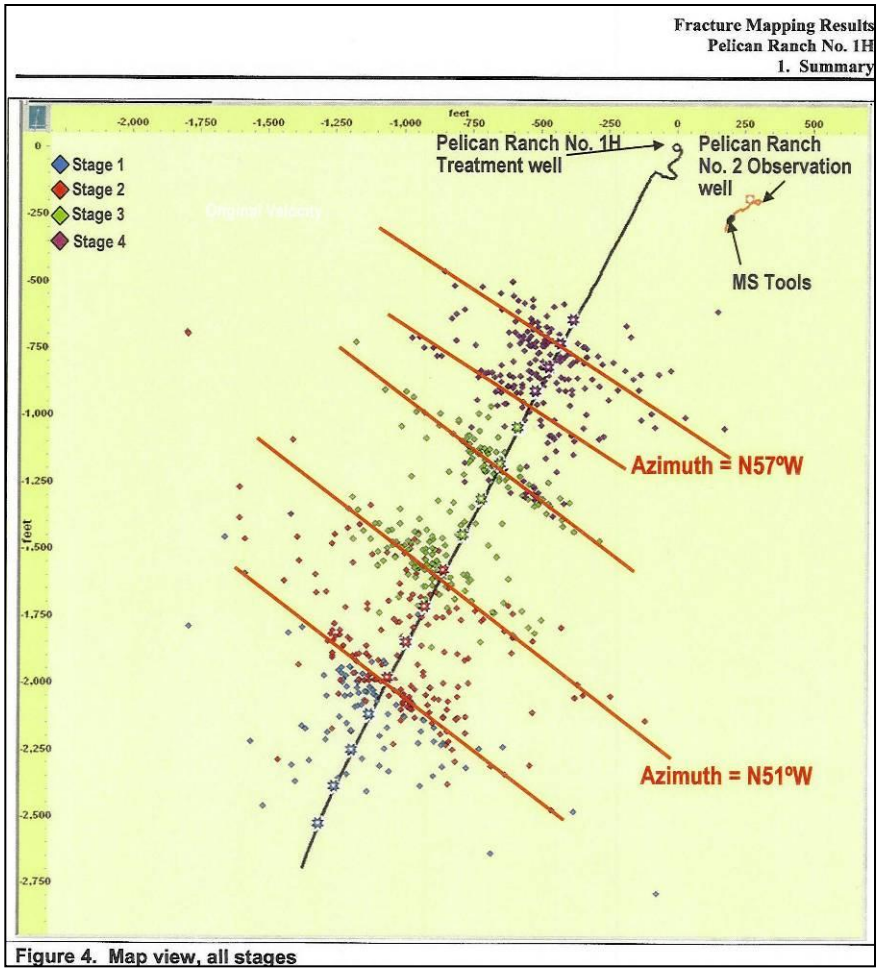
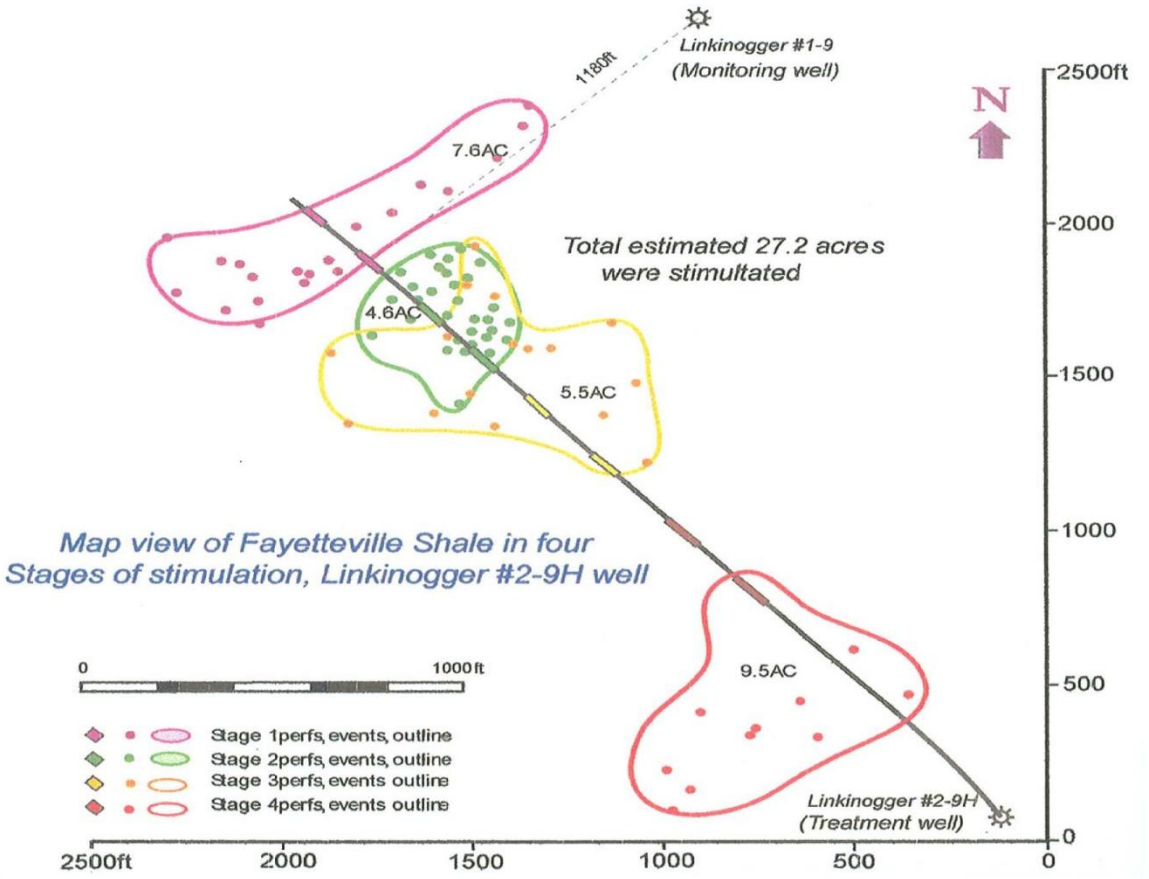


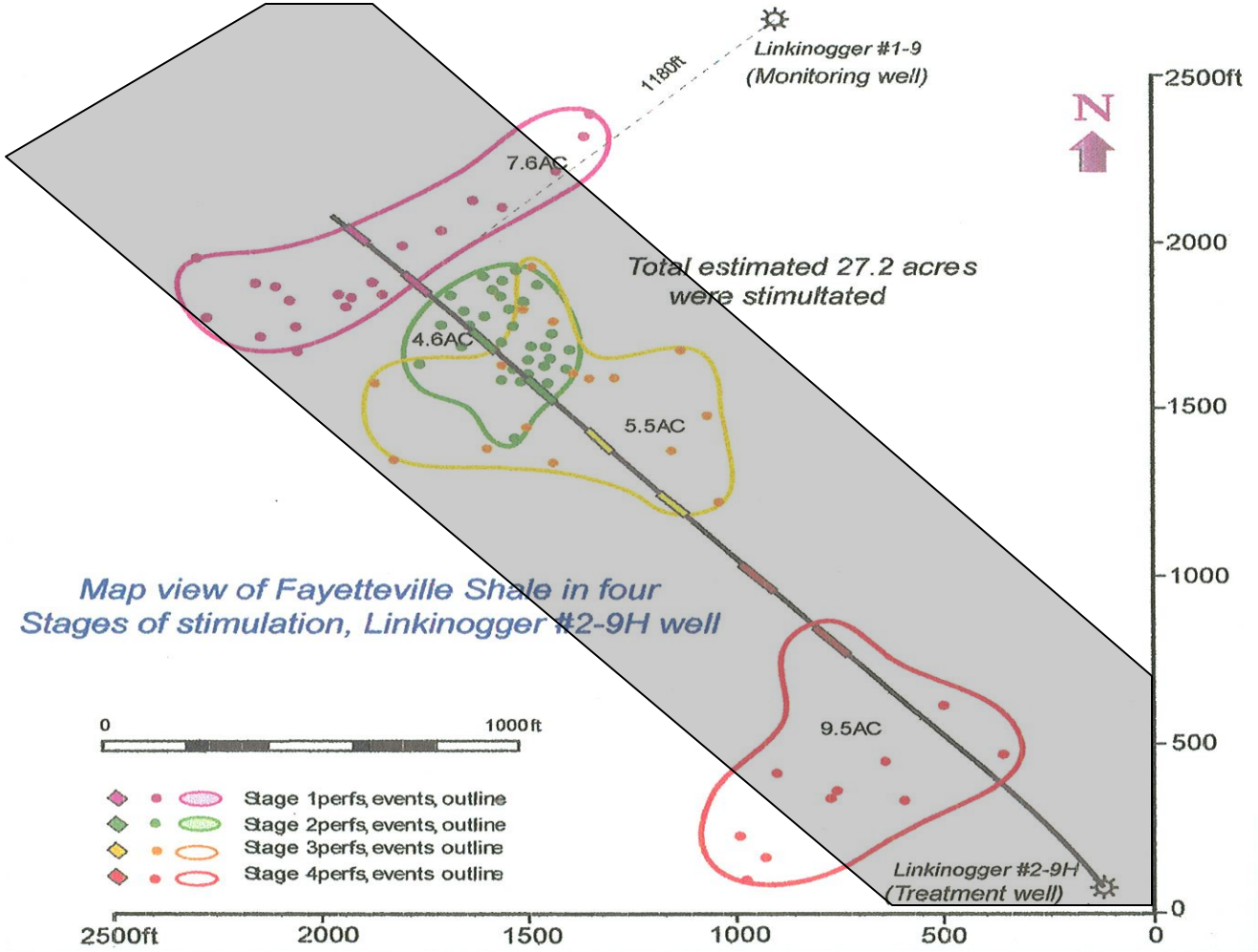
Figure 4. Map view, all stages

FRAC INTERFERENCE?

FRAC DISTRIBUTION



FRAC INTERFERENCE -DESIRED

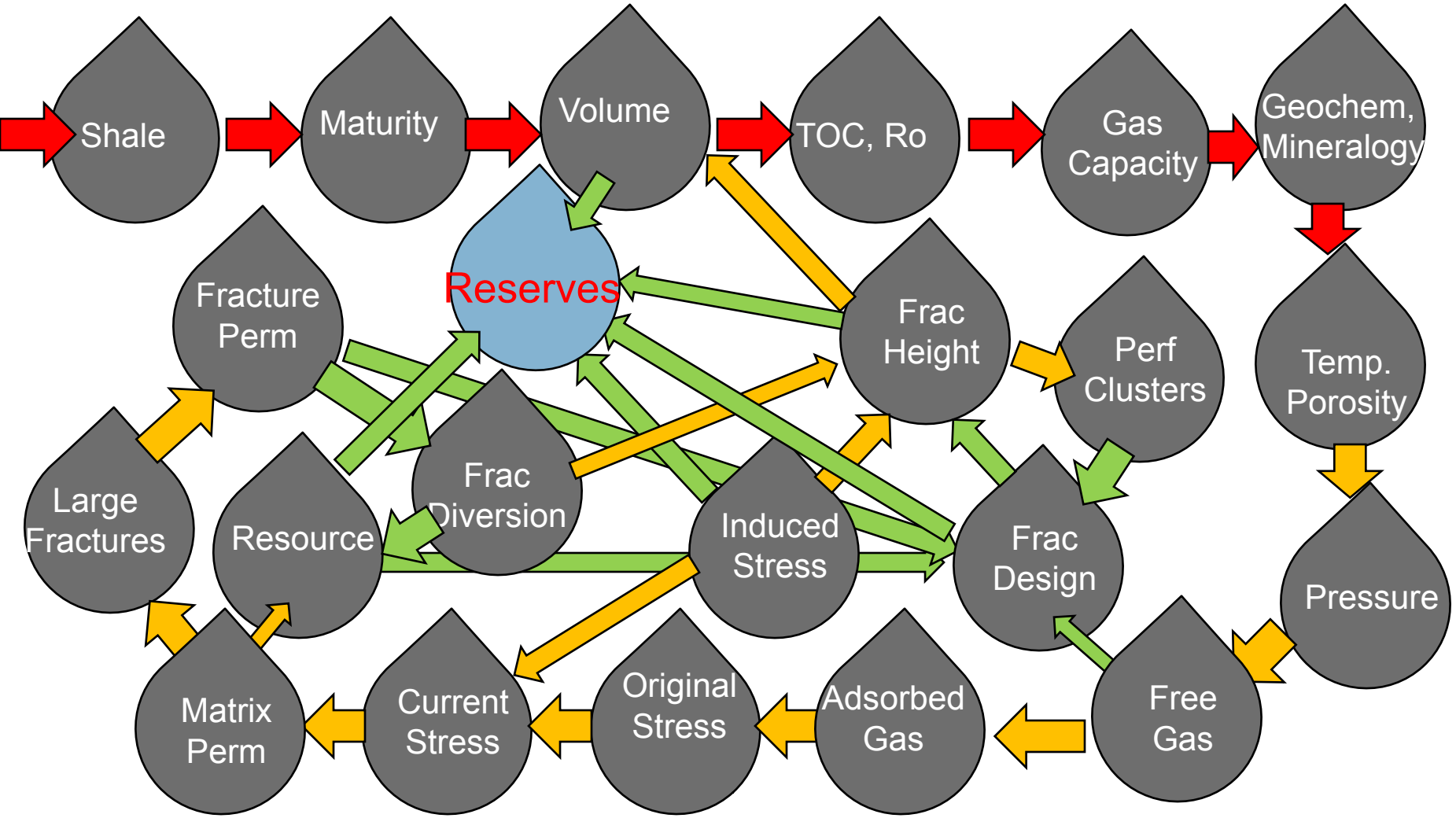


SOURCE: Southwesten Scotland Field 06.28.05 Field Rules Application

Their NEW roles in Resource Plays

- Together
  - A drilling plan is often considered before the drilling of the first well
  - Future drilling impacts data needs on the initial well(s)
    - How much 3D?
    - How much geochemistry is unknown, or uncertain
    - How well does the rock frac, what spacing might be expected?

So who is involved?



"Geoscience" Engineering Both

So who is involved?

- Everyone (alphabetically)
  - Engineering
    - Drilling
    - Completions
  - Facilities
    - Supply
    - Sales
  - Geology
  - Geophysics
  - Land

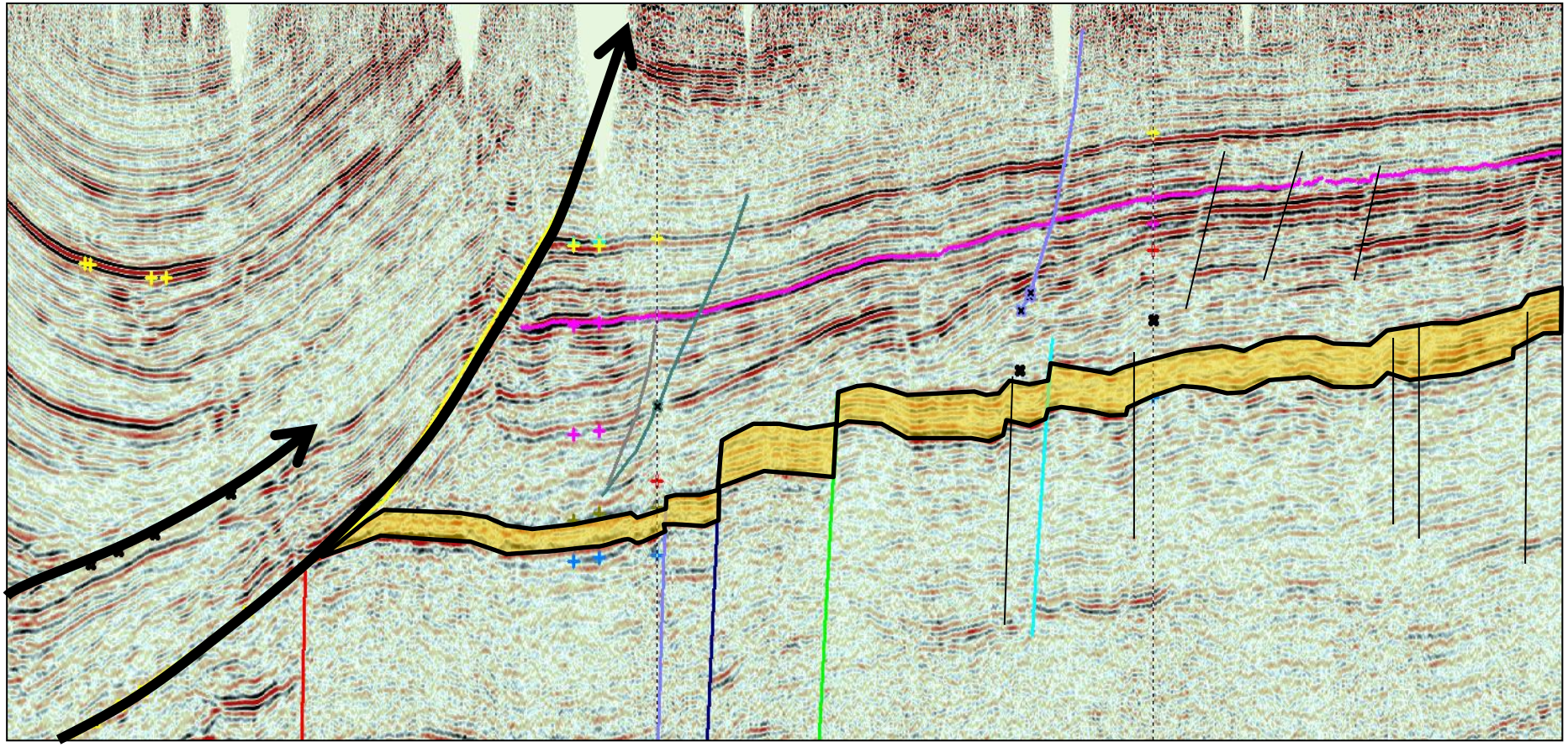
  - And let’s not forget management

So who is involved?

- Engineering
  - Drilling (focusing on horizontals)
  - Completions

- Drillers can drill it, but can completions complete it?
  - Key words – make an optimal completion

Vertical wells are easy, but horizontals?



Drilling

- Small casing = small hole = faster drilling = less cost
  - This can compromise frac
  - Increases friction, HP costs
  - Require more stages, more time and cost

- Smaller stages can reduce Stimulated Reservoir Volume (SRV)
  - Smaller SRV equates to smaller EUR
  - Smaller SRV means more wells needed to access all of the reservoir
  - More wells, more cost……

Upfront Planning and Good Communication

Can Lower Overall Project Costs

Geology, engineering

- Find the shale, identify the resource size
- Evaluate rock mechanics (with frac engineers)
- Evaluate frac performance – microseismic
- Change completion according to well performance during frac
  - This can avoid wasteful frac efforts
  - This can improve frac application during the job
  - Increase SRV
  - Geology, engineering, geophysics, geochemistry, logistics all involved in these changes

And Management

- Understand that shale plays are different than conventional plays
- Results take time
- First well(s) demonstrate project viability
  - May take hundreds of wells to optimize results
- Innovation and change (improvement) can best occur when left to those who are doing the work
  - Trust the workers you have and understand change cannot be scheduled.
  - The wells dictate what changes are needed
  - Hands on experience, balanced with continued scientific evaluation are your best tools

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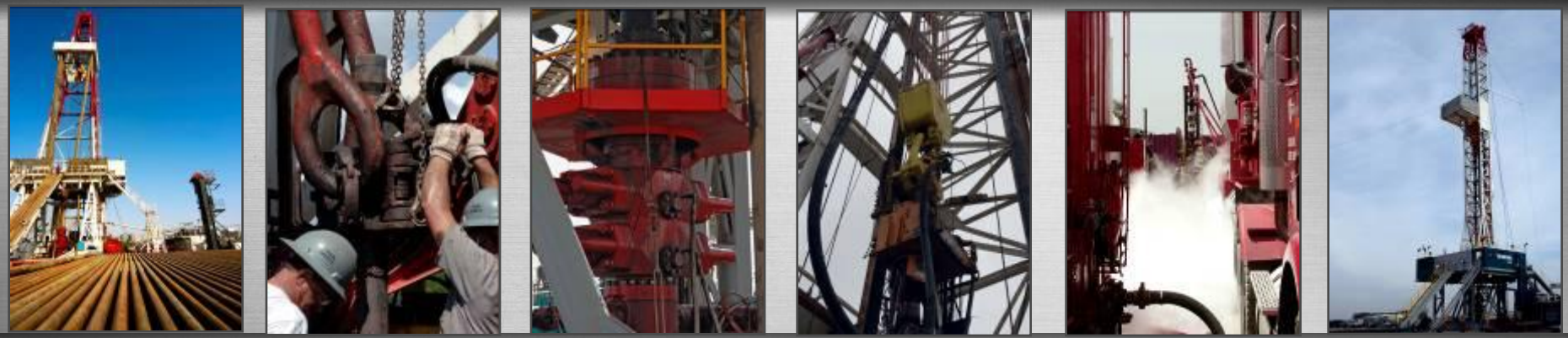

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