AV Hydraulic Fracture Seismicity in Tight Gas Sands:
A comparison of Canyon Sands and Cotton Valley treatments*

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Abstract

I have carefully analyzed microseismic data from two tight-gas sand reservoirs and find some striking features common to both data sets. The two field sites are the Carthage Cotton Valley gas field and the Sawyer Canyon Sands gas field. Both fields are located in Texas but are about 640 km apart. These reservoirs are fairly typical of the resource in which gas is produced from thick sequences of multiple, low-permeability sand layers that are interbedded with and isolated by shales. A common feature of both reservoirs is a prevalence of vertical tensile fractures contained within the individual sand layers. The fractures tend to be short (< 100 mm) and vertically discontinuous. These tensile fractures also terminate at shale boundaries and few, if any, occur in the intervening shales.

The microseismicity induced by hydraulic fracturing in these tight gas sands form long, narrow zones isolated within the sand intervals. Vertical fracture growth through the intervening shales occurs without detected seismic signal (aseismic growth). The source mechanisms indicate primarily shearing which occurs as strike-slip displacements along vertical fractures oriented close to the hydraulic fracture trends. Thus, the seismicity detected during stimulations highlights the preexisting fractures contained within the targeted sands. These are fractures that are intersected by or, are close enough to, the hydraulic fractures to be pressurized and accommodate some of the created volumetric strain. The temporal development of the seismic clouds indicates that the growth of the hydraulic fractures within the clouds are slow, too slow to generate seismically detected signals. The largely aseismic development of tensile failure and volume created is also indicated by the silent growth of the fractures through the intervening shales, where natural fractures are absent.

References

Eisner, L., J. Sileny, and J.T. Rutledge, 2004, Moment tensors of events induced in Cotton Valley gas field from waveform inversion (abstract): 66th EAGE Conference & Exhibition.

Laubach, S.E., and E. Monson, 1988, Coring-induced fractures: indicators of hydraulic fracture propagation in a naturally fractured reservoir: Proceedings, SPE Annual Technical Conference and Exhibition, Houston, Tex., SPE Paper 18164, p. 587-596.

Marin, B.A., S.J. Clift, H.S. Hamlin, and S.E. Laubach, 1993, Natural fractures in Sonora Canyon sandstones, Sonora and Sawyer fields, Sutton County, Texas, *in* Rocky Mountain Regional Meeting/Low Permeability Reservoirs Symposium: Society of Petroleum Engineers, SPE Paper 25895, p. 523−531.

Sileny, J., L. Eisner, D.P. Hill, and F.H. Cornet, 2008, Non-double-couple Mechanisms of Microearthquakes Induced by Hydraulic Fracturing (abstract): 70th EAGE Conference & Exhibition

Vavrycuk, V., 2001, Inversion for parameters of tensile earthquakes: Journal of Geophysical Research, v. 106(B8), p. 16,339–16,355.

Hydraulic Fracture Seismicity in Tight Gas Sands

A Comparison of Canyon Sands and Cotton Valley Treatments

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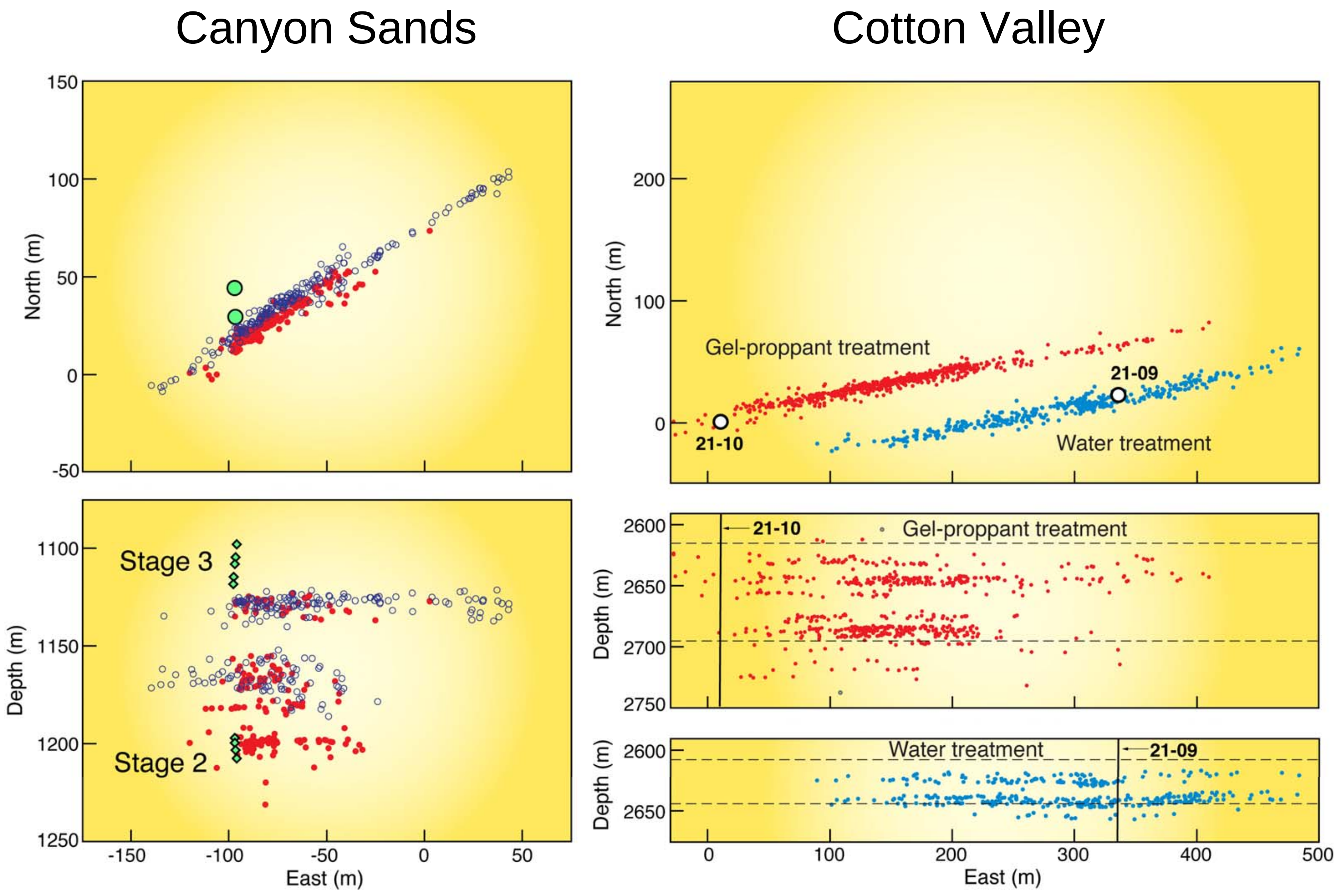
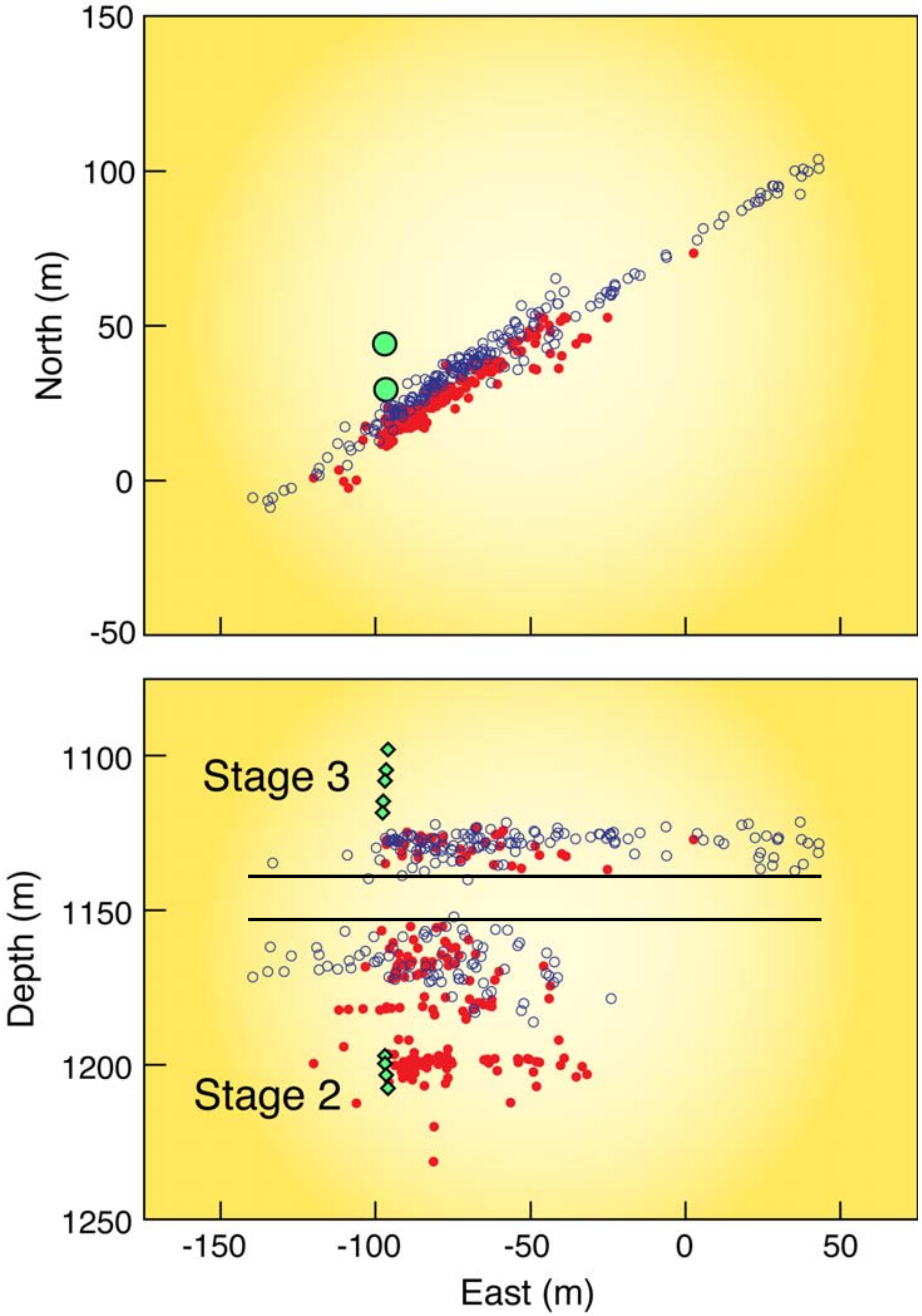
Outline of talk

- Show the similarities of the Cotton Valley and Canyon Sand hydraulic-fracture seismicity
  - Aseismic fracture growth through shales
  - Source mechanisms
  - Common geology
- Why don’t we seismically detect the fracture opening events?



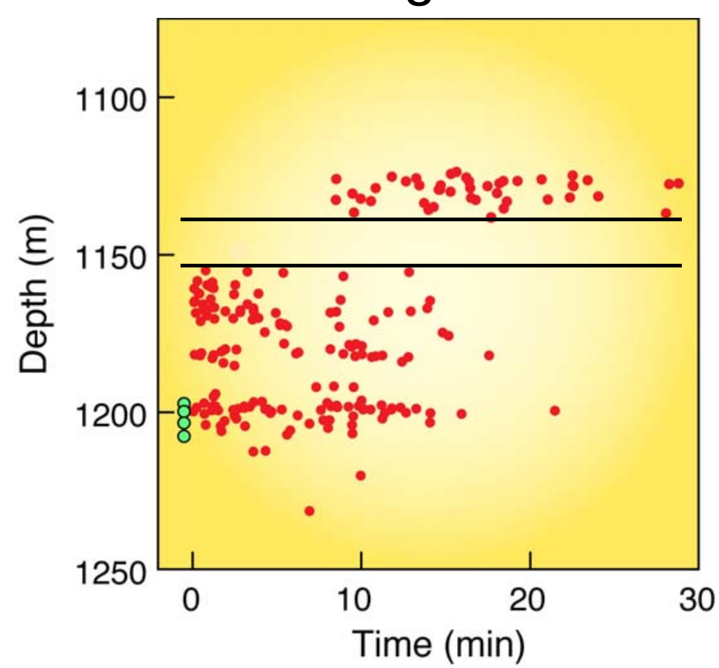
Canyon Sands
Cotton Valley
North (m)
Depth (m)
East (m)
Stage 3
Stage 2
Gel-proppant treatment
Water treatment
21-10
21-09

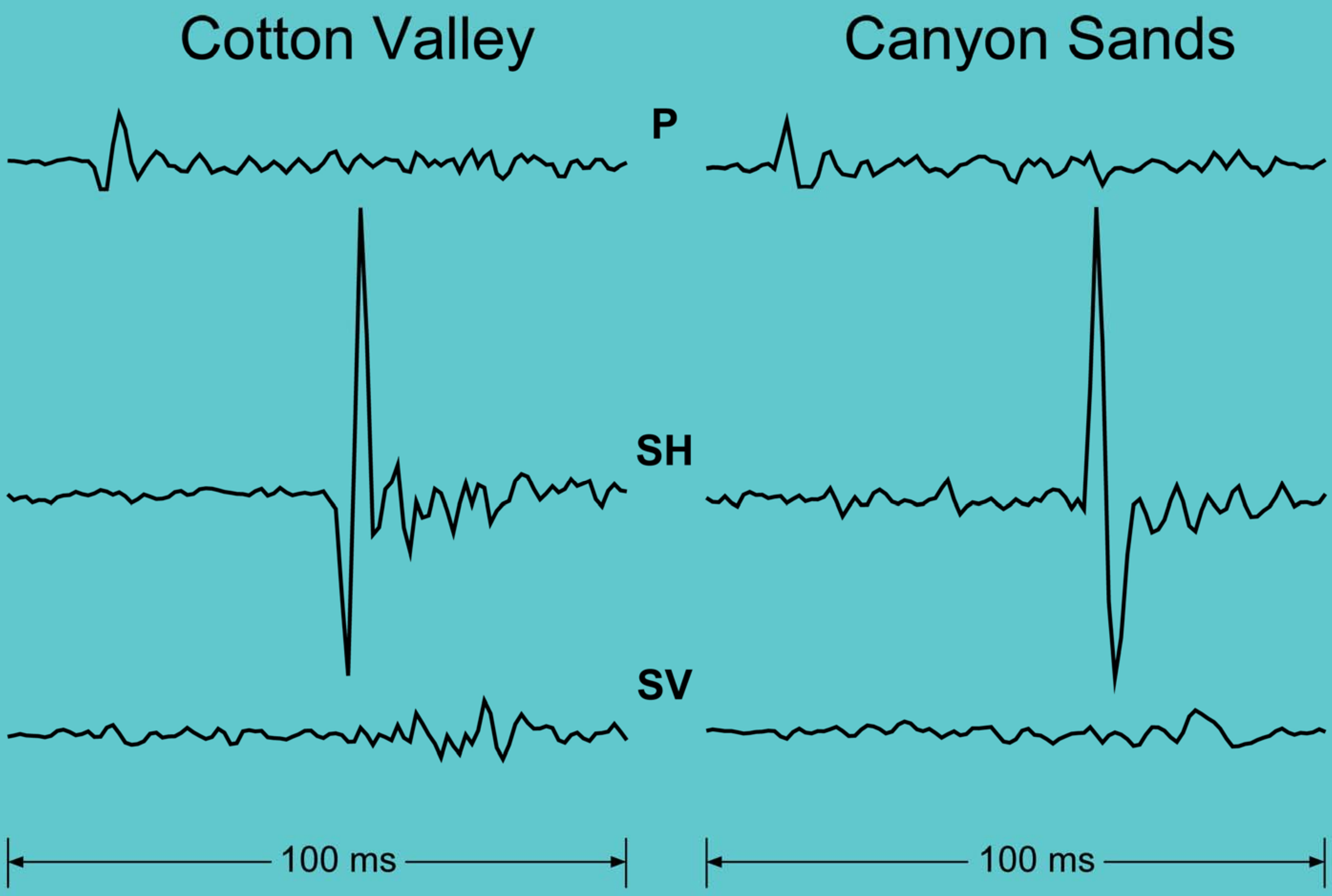
Canyon Sands



Upward growth rate through shale is about 3 cm/sec

Temporal Growth Stage 2

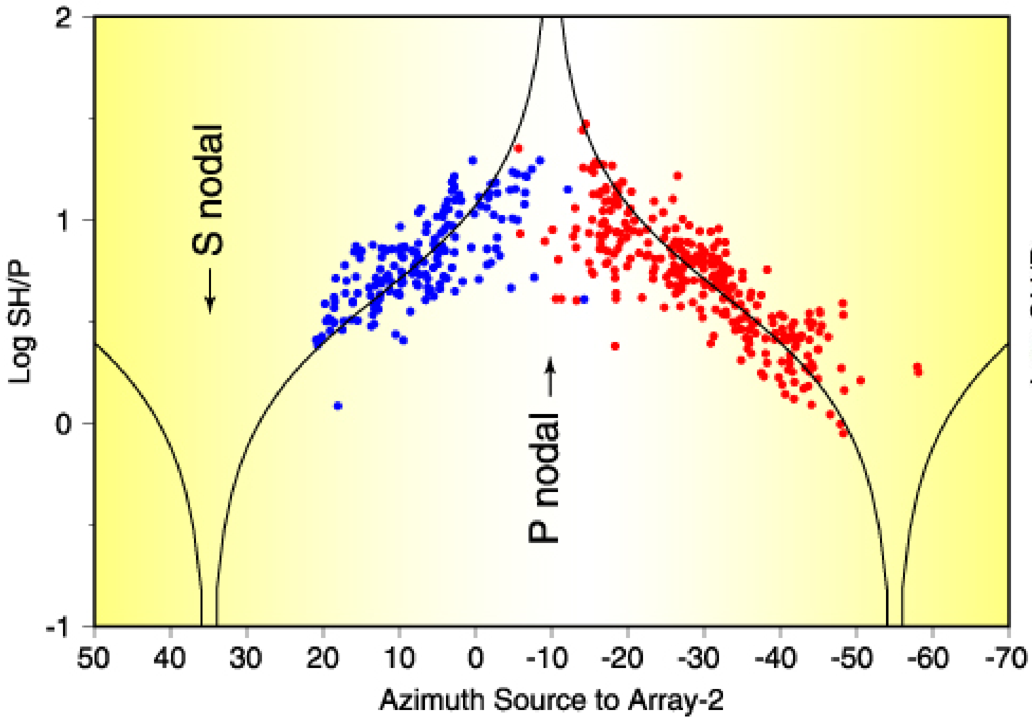


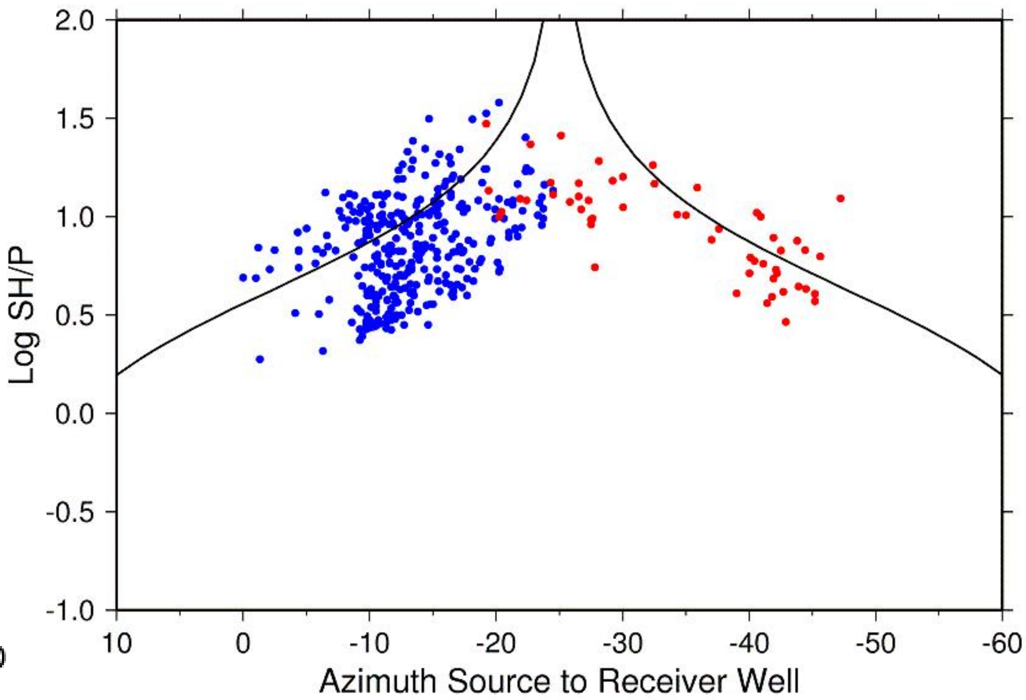


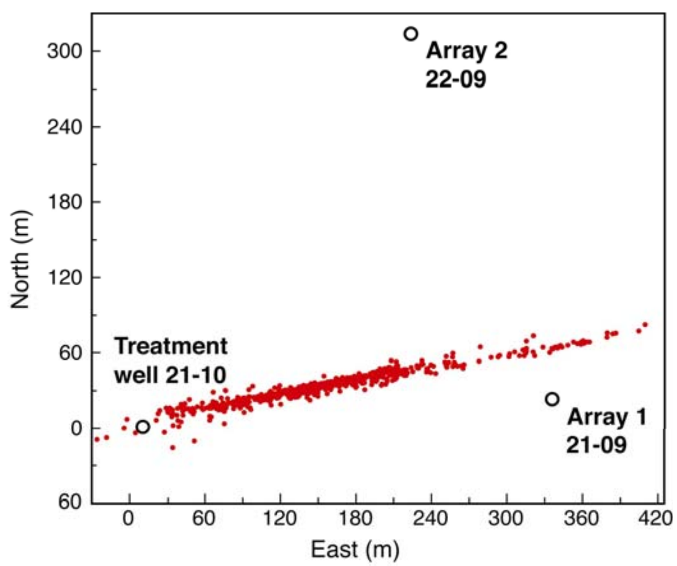
Cotton Valley
Canyon Sands
P
SH
SV
100 ms
100 ms

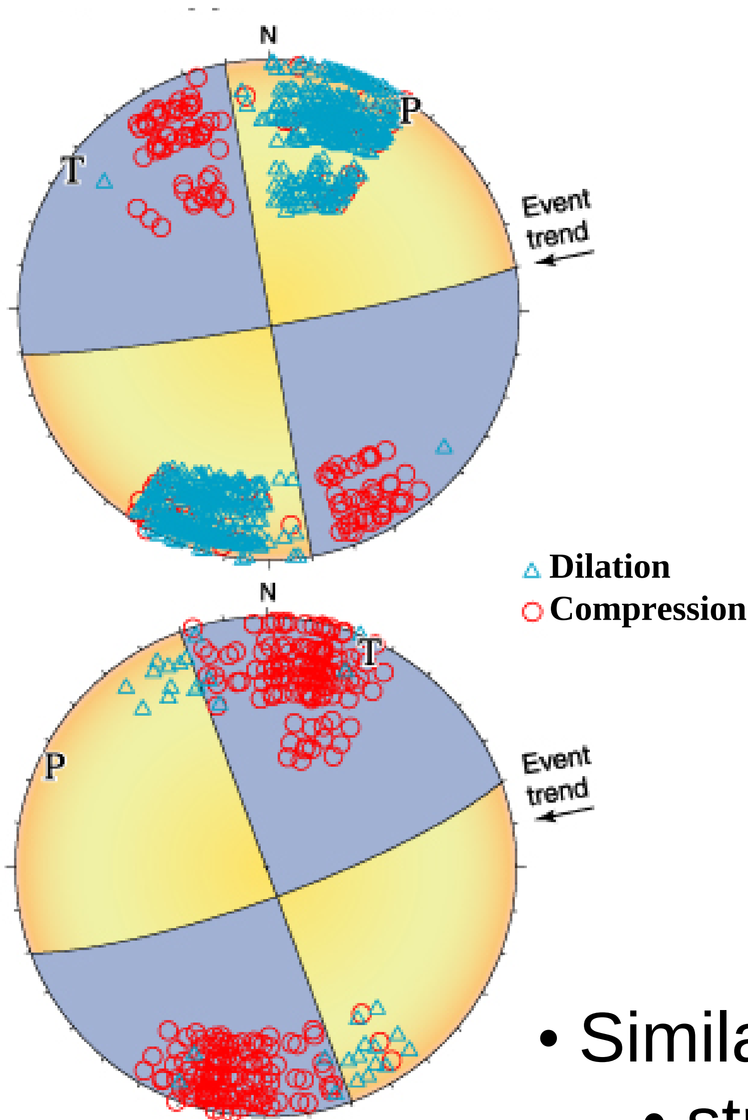
Cotton Valley SH/P

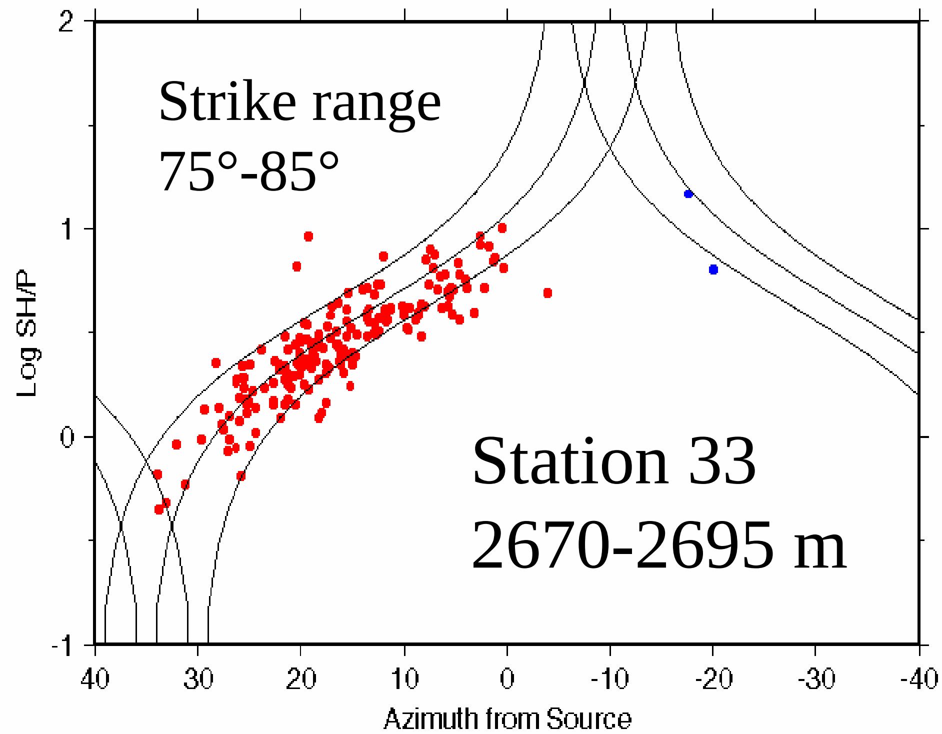
Canyon Sands SH/P



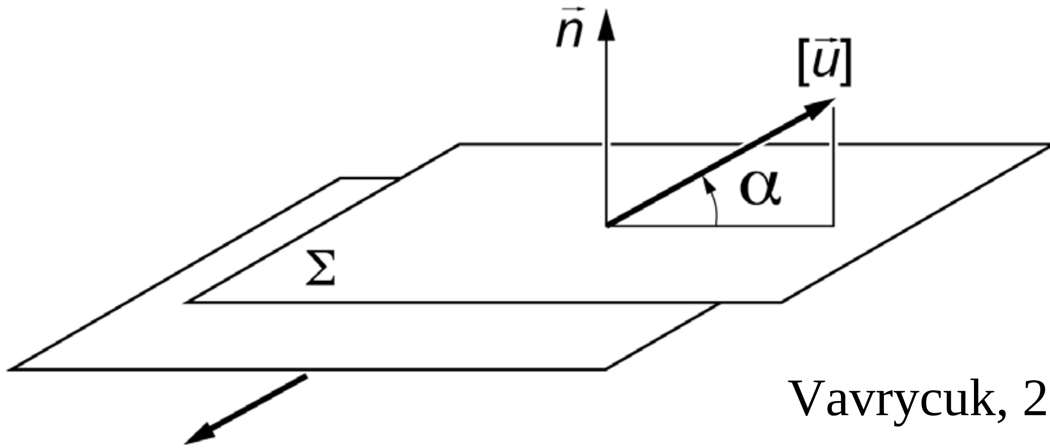




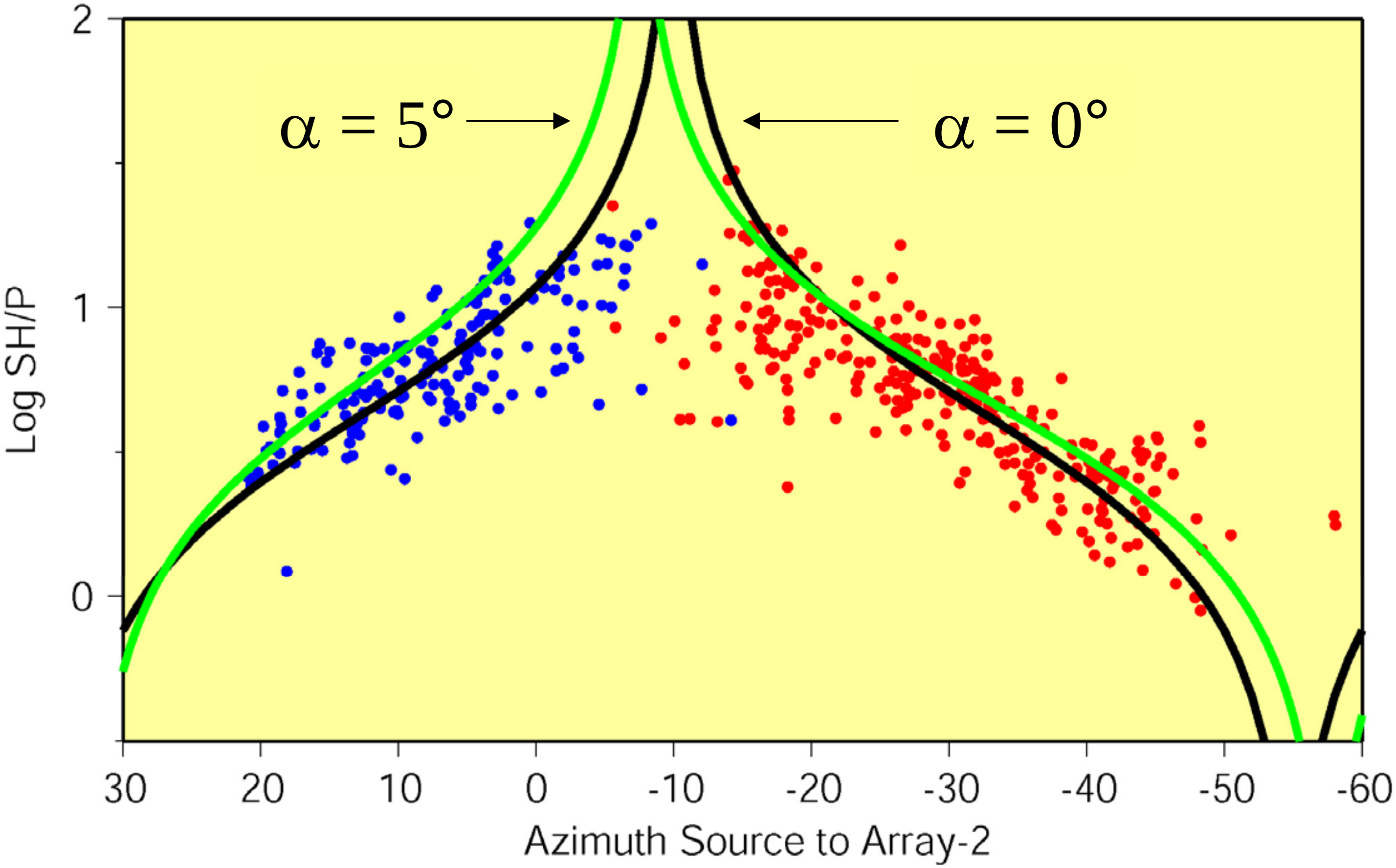




- Similar mechanisms throughout treatments
  - strike-slip on vertical fractures close to hydraulic fracture trend (±10º)



Vavrycuk, 2001 *JGR*

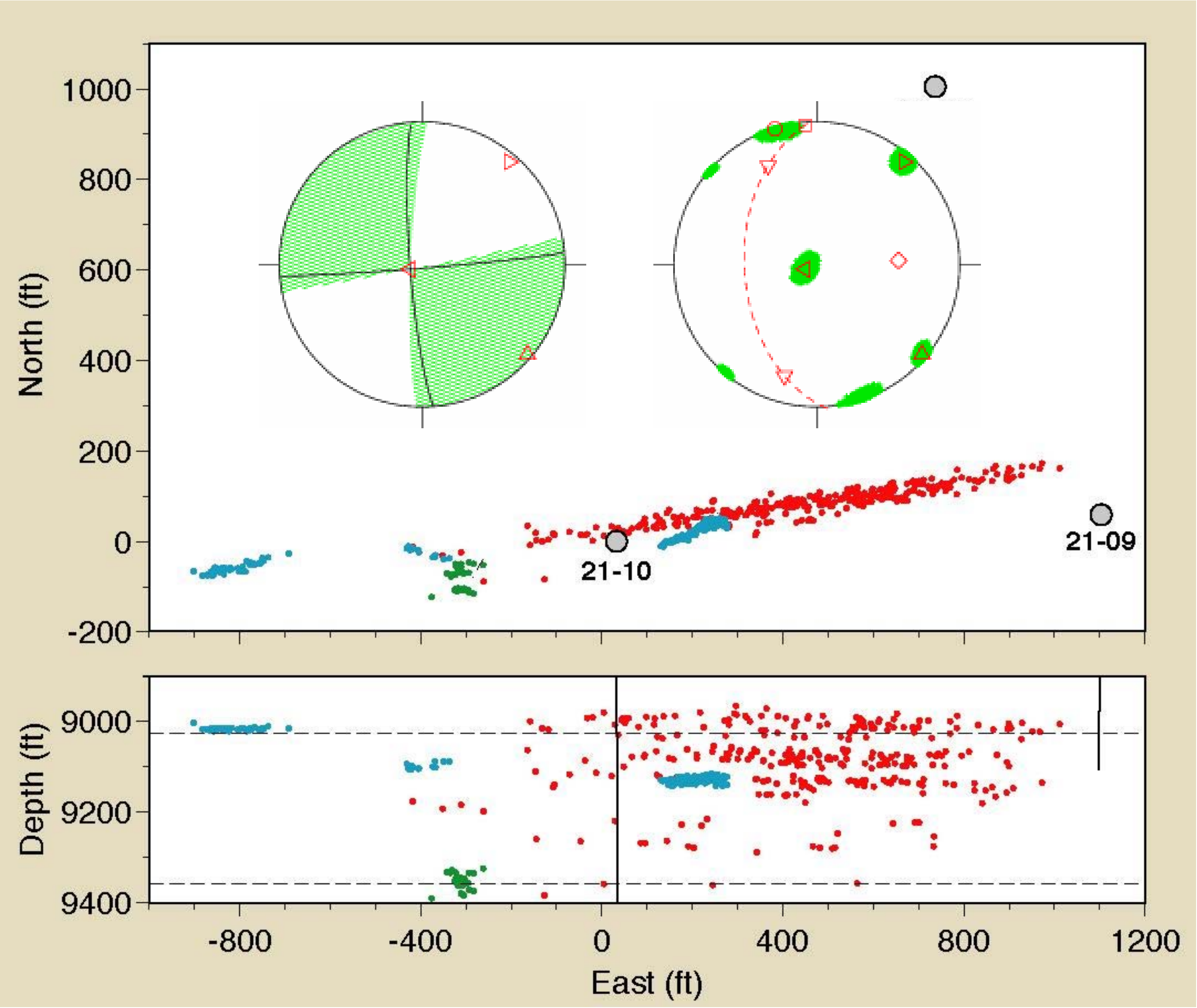


α = 5°
DC = 78%
CLVD = 10%
ISO = 12%

Cotton Valley Stage 2

Full Moment Tensor Solution

Sileny et al



NRMS=0.13

DC	63%
CLVD(T)	25%
ISO(expl)	12%

Common Geology

- Natural fractures are contained within the sands
  - These are vertical tensile fractures
  - The intervening shales contain few if any fractures
- Fracture orientations:
  - Cotton Valley prevalently trend subparallel to S_{Hmax}
  - Canyon Sands are more diverse
    - An FMS log did show a prevalence of fractures to be within 10° of S_{Hmax} -- but no effort made to resolve natural from drilling induced fractures

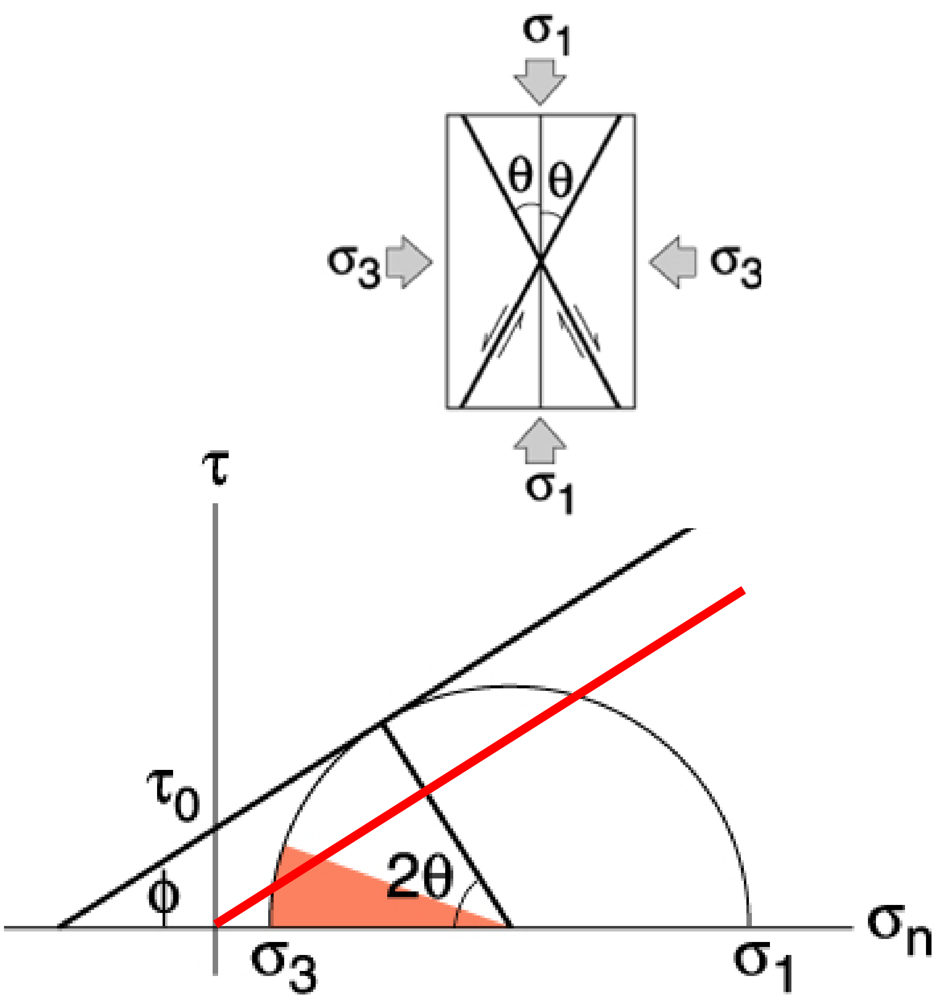
Laubach and Monson, 1988; Marin et al., 1993; Miller et al., 1994

Summary

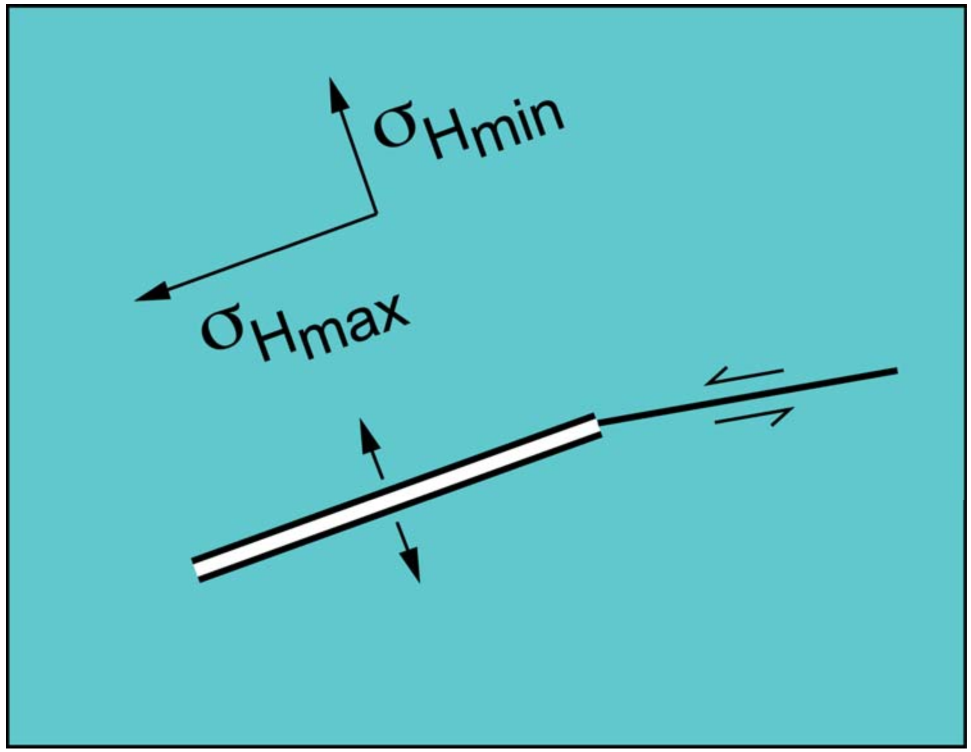
- The banding of seismicity and the slip plane orientations are consistent with activation of the reservoirs natural fractures contained within the sands
- Aseismic fracture growth occurs within the intervening shales, where no natural fractures are present

How do we get shear along fractures close to hydraulic fracture orientation?

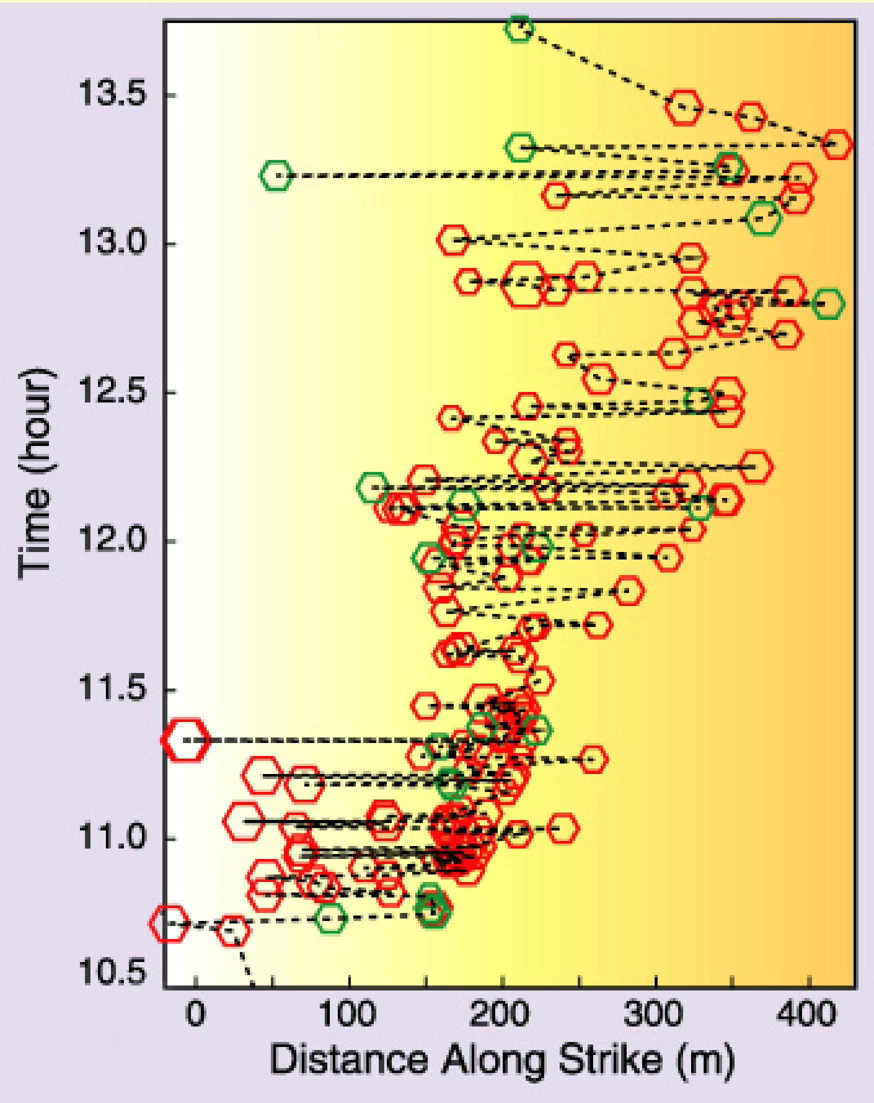
1. Pore pressure reducing effective normal stress



2. Hydraulic opening translating to shear along intersecting fractures



Why don't we "seismically" see fracture opening that accompanies shear?



The movement of the seismic front is slow, about 3 to 6 cm /sec

- suggesting fluid invades the fracture network slowly

The seismic source dimensions are on the order of ~2 m

- time to infiltrate that length of fracture is about 25 seconds or more

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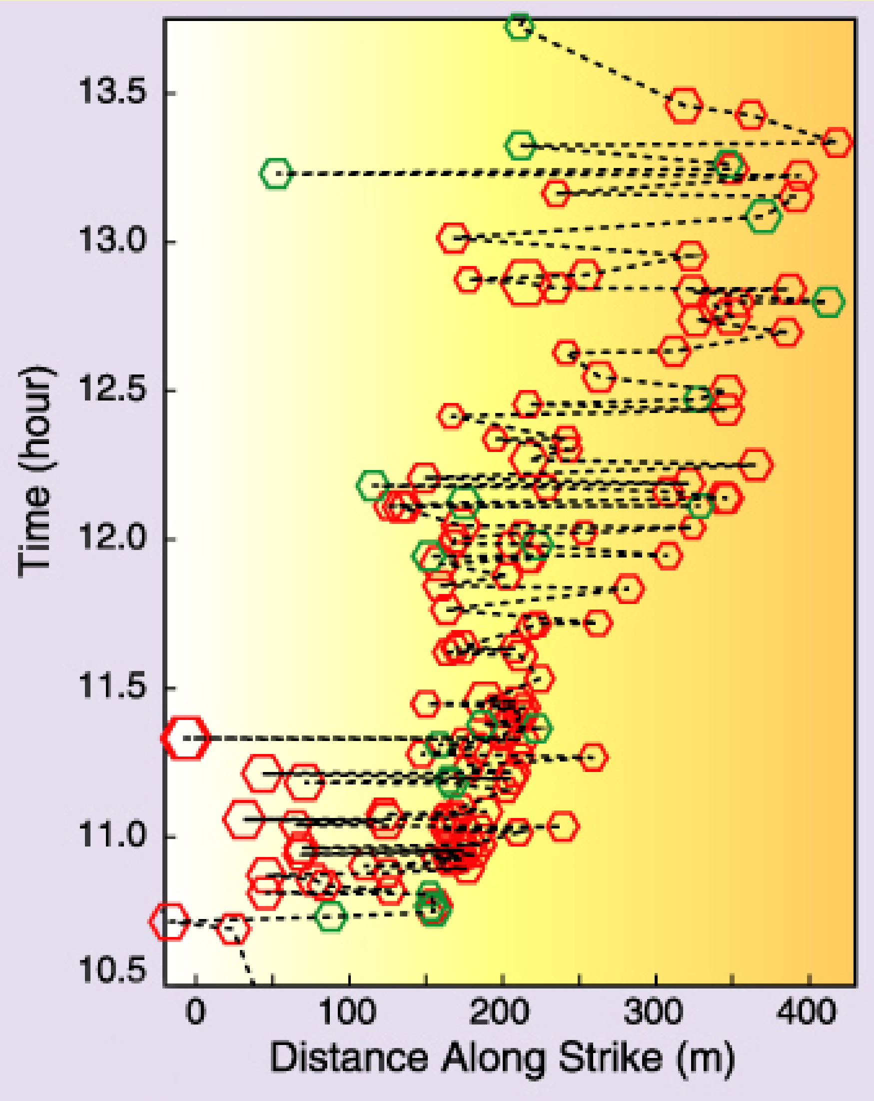

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- Fracture opening is a slow stable process – outside of our seismic bandwidth

- Whereas shear failure occurs critically at threshold pore pressures or when shear stresses induced by adjacent opening exceed fracture strength

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