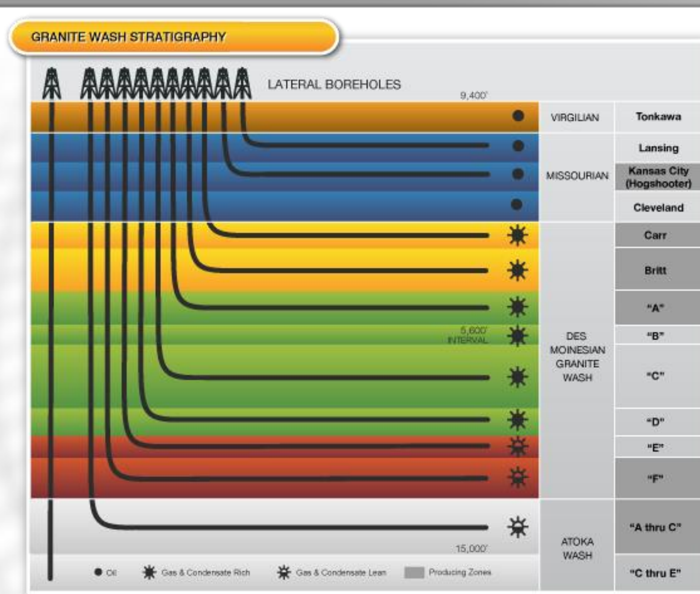
Hydraulic Fracture Characterization from Microseismic Data in the Granite Wash

Jamie Rich

How can microseismic help in the Granite Wash?



2

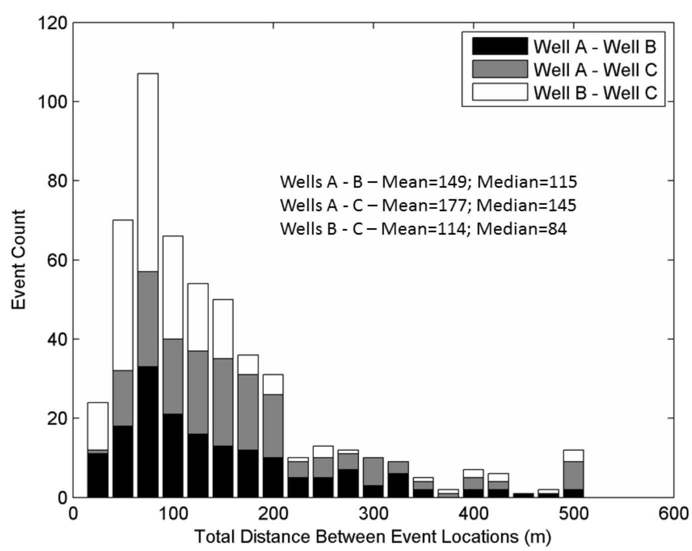
From: http://www.linnenergy.com/operations/midcontinent-ops.htm

Microseismic for Characterizing Fracture Growth

- We routinely use microseismic to characterize the extent of hydraulic fracturing
- This can be particularly useful in the Granite Wash for both vertical and horizontal spacing
- Case Study to understand precision of event location
  - 10 stage completion in Hemphill co.
  - Events co-located using three monitor wells
  - Examined a subset of three stages to address precision before interpreting event locations
- Characterizing Fault Plane Solutions and what they can tell us about hydraulic fracture growth

3

Individual Well Comparisons



15

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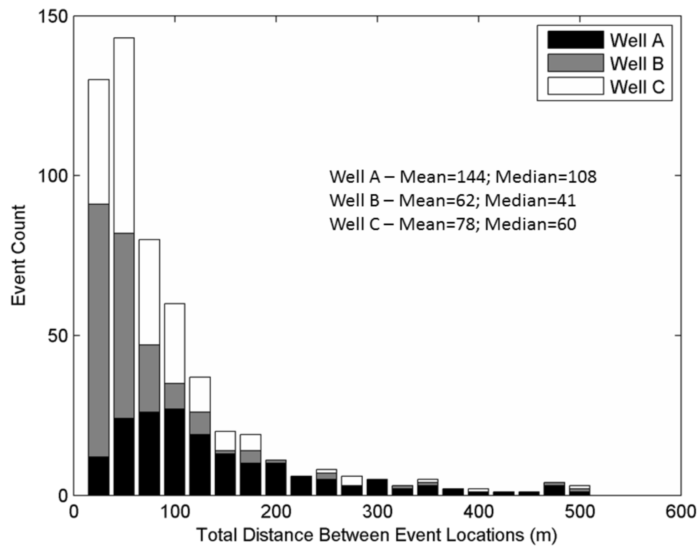
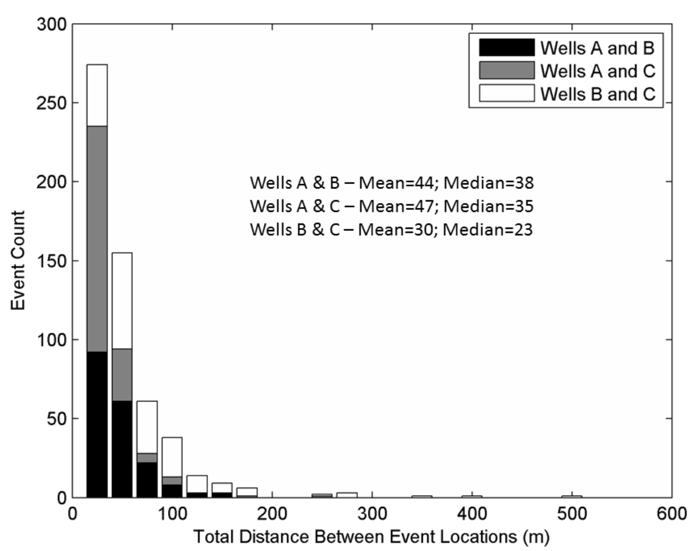
Individual Well Solutions



16

Two Well Solutions



17

But what are microseismic events?

Some researchers suggest that through Moment Tensor Inversion we can see opening and closing of tensile fractures.

Others suggest that events are predominantly shear

- pre-existing fractures or accommodation failure related to hydraulic fracture growth

Termination at bed boundaries may manifest as a different mechanism.

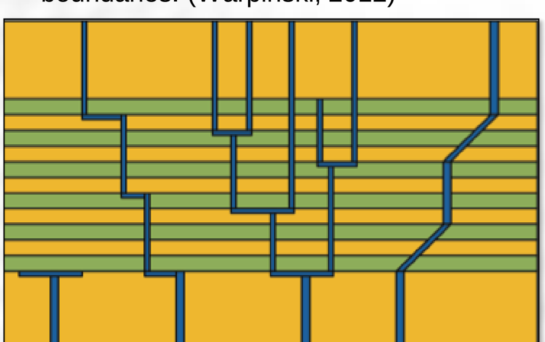
If we better understand the mechanism, can we:

- Predict height growth?
- Adjust treatment parameters to maximize (or minimize) height growth?

Fracture Height Growth

Vertically changing lithologies can limit height growth of hydraulic fractures as observed in mineback and laboratory experiments.

- Blunting and offset of fractures have been observed at bed boundaries. (Warpinski, 2012)



Schematic of different pathologies of fracture behavior in a layered sequence. All have been observed in minebacks or laboratory tests. (Warpinski, 2012)

Mineback photograph (and line drawing) of fracture kinking, offsetting, and turning as interface is crossed (Warpinski, 2012)

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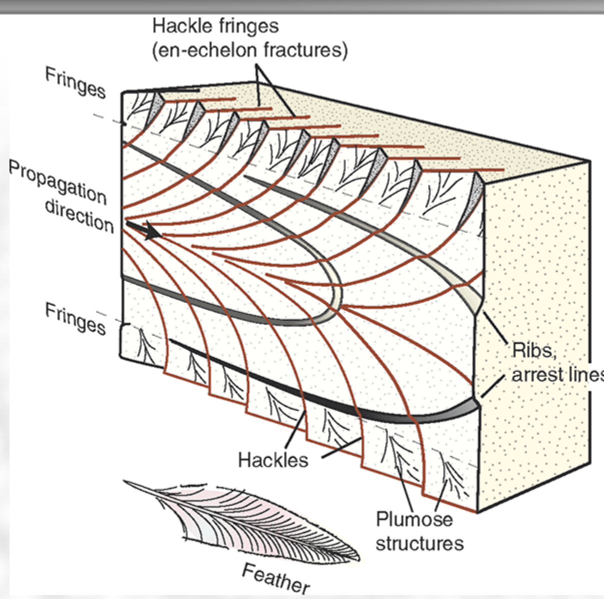
Horizontal fracturing?

Horizontal fracture sliding can initiate along an interface because of existing shear stresses at the interface. (Daneshy, 2009)

There is evidence of horizontal fracturing from diagnostic measurements in layered media based on tilt-meter and radioactive tracer data. (Baree, 2010)

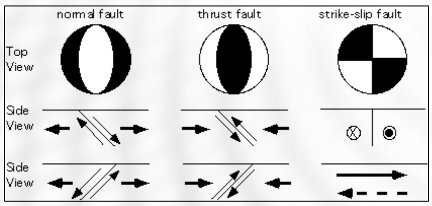
Proppant filled re-oriented horizontal fracture near the interface (Daneshy, 2009)

Associated Shear

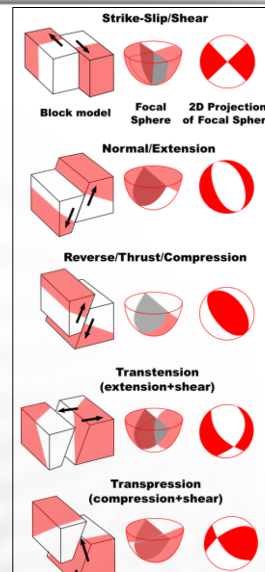


Rutledge 2014

Fault Plane Solutions



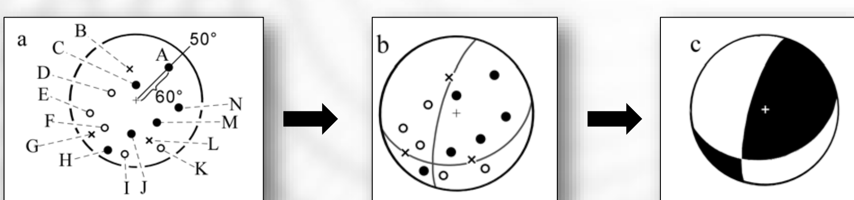
Depiction of how two different fault plane motions can come from the same P-wave motion (Hsui, 1998)



Rowan, 2009

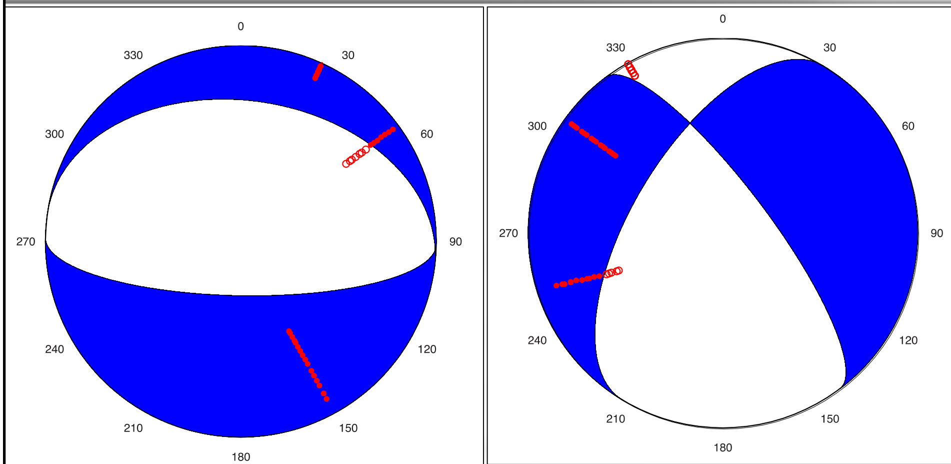
Fault Plane Solutions

Stn	P wave	symbol	Stn	P wave	symbol	Stn	P wave	symbol
A		●	F		○	K		○
B		×	G		×	L		×
C		●	H		●	M		●
D		○	I		○	N		●
E		○	J		●			



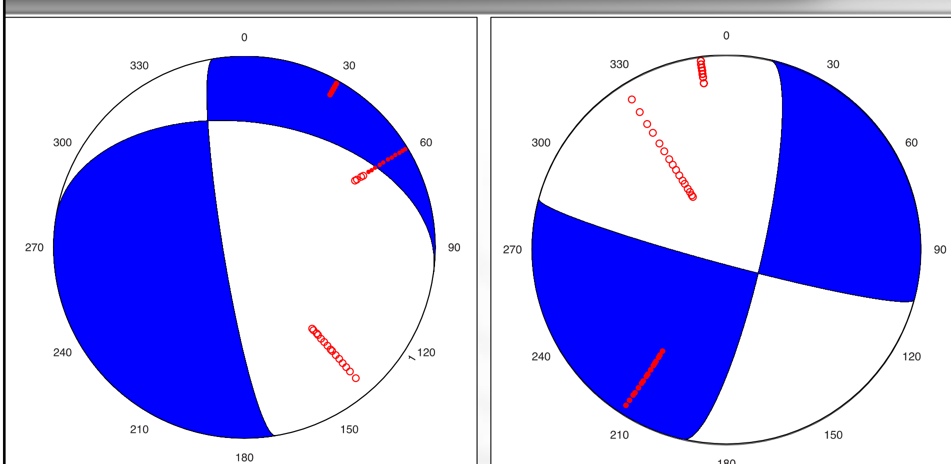
Cronin, 2010

Fault Plane Solutions of Shallow Events



Blue= compression (down)
White= dilatation (up)
Solid dots= down
Circles= up

Fault Plane Solutions of Shallow Events



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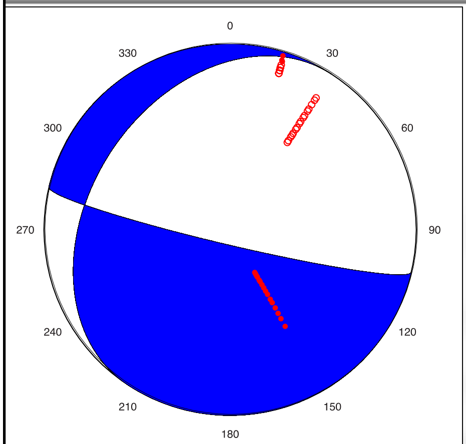
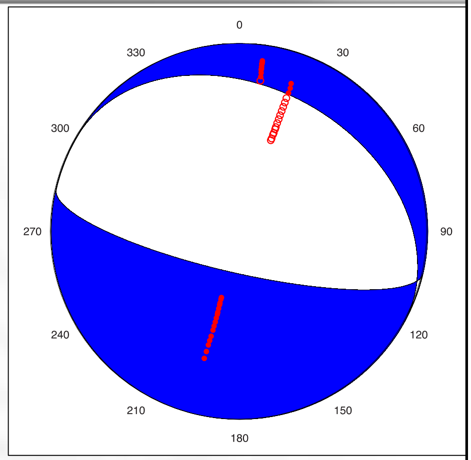
Fault Plane Solutions of Deeper Events





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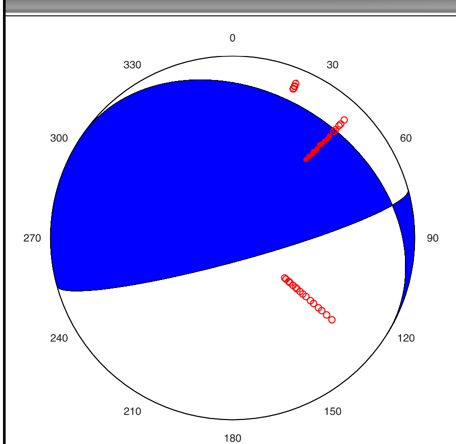
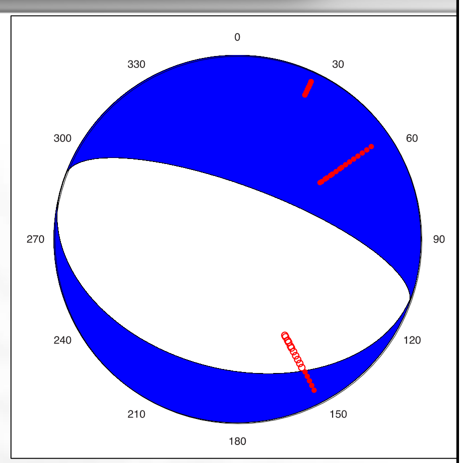
Fault Plane Solutions of Deeper Events





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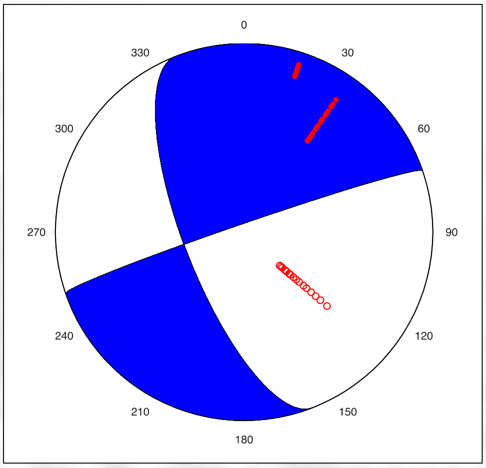
Fault Plane Solutions of Deeper Events



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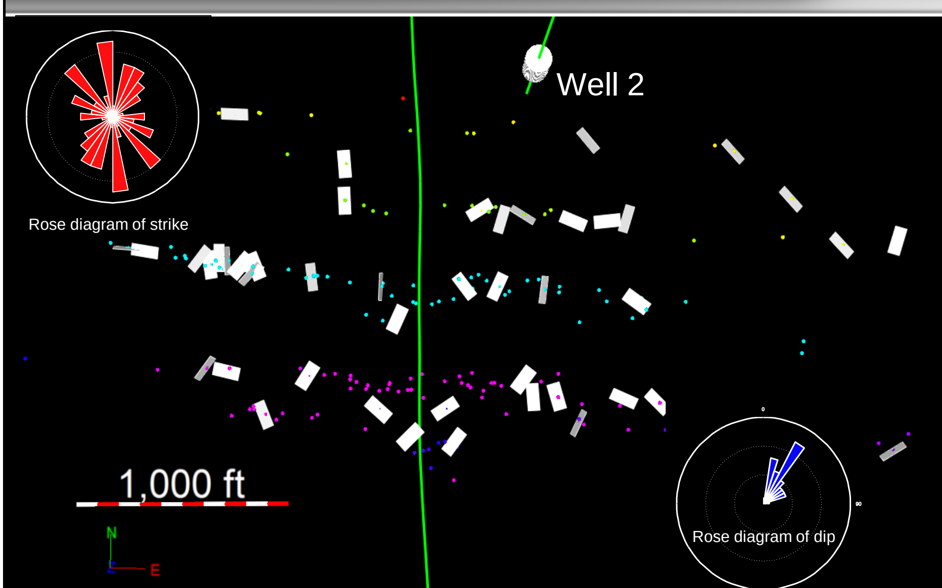
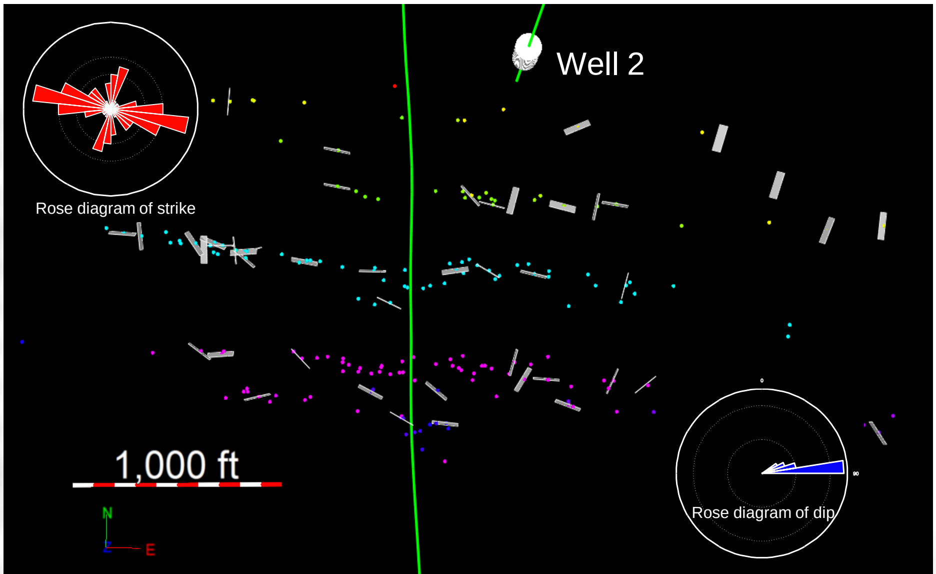
Shallower nodal planes



Steeper dipping nodal planes



30

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Conclusions

- Multiple wells (at least two) significantly improves event locations
  - Fractures in the Granite Wash appear significantly narrower with multi-well solution
- Fault plane solutions separate into two populations
  - -Strike-slip events oriented close to regional stress direction
  - -Dip-slip events near horizontal (or vertical)
- Vertical event locations are not precise enough to correlate FPSs with bounding formations

31

Future Work

- Relocation of events using cross correlation
  - -Has been shown to dramatically improve location of events
- Fault plane solutions for all of the high quality events
- Inclusion of S/P amplitude ratios in fault plane solutions
- Integration with azimuthal anisotropy and attributes from 3D seismic

32

Acknowledgements

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33