Hydraulic Fracture Characterization from Microseismic Data in the Granite Wash

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How can microseismic help in the Granite Wash?

[Diagram of Granite Wash Stratigraphy]

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

Well A – Mean=144; Median=108
Well B – Mean=62; Median=41
Well C – Mean=78; Median=60

Two Well Solutions

Wells A and B – Mean=44; Median=38
Wells A and C – Mean=47; Median=35
Wells B and C – Mean=36; Median=23
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 minebacks 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)
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)

Associated Shear

Hackle fringes (en-echelon fractures)

Propagation direction

Fringes

Plumose structures

Ribs, arrest lines

Fringes

Hackle

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

Fault Plane Solutions

Fault Plane Solutions
Fault Plane Solutions of Shallow Events

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

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Rich
Fault Plane Solutions of Deeper Events

Blue = compression (down)
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Shallower nodal planes

Rose diagram of strike
Rose diagram of dip

1,000 ft
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
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

Acknowledgements

University of Oklahoma Granite Wash Consortium
Devon Energy for providing the data
Ron Kerr (formerly Devon Energy), Sara Long (Devon Energy), Ian Stark (OU MS student)