Natural Fracture Characterization

Julia Gale, Stephen Laubach, Jon Olson

Operators in the Marcellus Shale gas play are aware of the importance of natural fractures. There has been substantial work on the fracture systems in the very large region covered by this play (eg. Lash and Engelder, 2005, 2007, 2009). The emphasis of this work has been on uncemented joints that are seen in outcrops and recognition of bitumen-filled microcracks developed during catagenesis. By contrast, studies by The University of Texas (UT) fracture research group of several producing or prospective gas-bearing shales shows that fractures in shales are typically present in most cores but they are commonly narrow and sealed (Gale, et al., 2007). In most shale-gas plays that are being produced using hydraulic fracturing stimulation these fractures are nevertheless important because of their interaction with hydraulic treatment fractures (Gale et al., 2007). Moreover, at the scale of a fracture stimulation, fracture patterns and in situ stress can be highly variable, even though the broad tectonic pattern may be consistent over 100s of miles. Thus, site specific evaluation of the natural fractures and in situ stress is necessary. Analogy with the Austin Chalk and the Niobrara Formation suggests that open fractures may also be present, but they are likely to be concentrated in clusters spaced hundreds of feet apart (Gale, 2002; Gale et al., 2007). Our goal for this project is to characterize the fractures, identify the characteristic spatial arrangement of fractures, including potential clusters of large fractures. We will use new concepts of quantification of fracture spatial arrangement that we helped develop.

Our emphasis will be on characterizing, quantifying and modeling fractures that have grown in the subsurface in a chemically reactive environment through a combination of observation at a range of scales, detailed petrographic and microstructural observation of cement fills, and geomechanical modeling (cf Marrett et al., 1999; Gale, 2002; Laubach 1997, 2003; Olson, 2004). Large natural fractures, open or sealed, are typically sparsely sampled in core or image logs. The approach pioneered at UT allows operators to overcome the sampling problem that prevents systematic sampling of the large fractures that can augment gas production or influence the growth of hydraulic fractures.

Scope of Work

Key parameters of orientation, size distribution, intensity and porosity/occlusion patterns can be assessed through examination of a combination of data types, the most important of which would be cores and vertical and horizontal well image logs. We can also make use of image logs and drilling and production reports. We will select samples from the cores to be made into polished thin sections to examine the mineral fill of the fractures. Our main tasks will be as follows:

1. Extract fracture orientation, intensity and spatial distribution information from core and log data. We will also need to determine how many fracture sets there are and their relative timing. Attributes for each set will be assessed separately.
2. Collect and analyze thin section and scanning electron microscope (SEM) imagery.

We will need to establish the degree to which fractures are sealed with mineral cements, and the crossover size (emergent threshold; Laubach, 2003) for sealed to open fractures.

3. Use site-specific fracture and *in situ* stress attributes as input parameters for geomechanical modeling of fracture patterns in the two areas. The modeling will be done using *JOINTS* software, developed by Dr. Olson. Fracture orientation, fracture-fill and size-distribution data, collected during task 1, together with measurements of subcritical crack index and mechanical layer thickness and properties will be used as model input.
4. Compare modeled fracture patterns with data from outcrops and core analysis, and microseismic monitoring data where available.

References

Gale, J. F.W., 2002, Specifying lengths of horizontal wells in fractured reservoirs: Society of Petroleum Engineers Reservoir Evaluation and Engineering, p. 266–272.

Gale, J. F. W., S. E. Laubach, R. A. Marrett, J. E. Olson, J. Holder, and R. M. Reed, 2004, Predicting and characterizing fractures in dolostone reservoirs: Using the link between diagenesis and fracturing, in C. J. R. Braithwaite, G. Rizzi, and G. Darke, eds., The geometry and petrogenesis of dolomite hydrocarbon reservoirs: Geological Society (London) Special Publication 235, p. 177– 192.

Lash, G., and Engelder, T. 2009, Tracking the burial and tectonic history of Devonian shale of the Appalachian Basin by analysis of joint intersection style. Geological Society of America Bulletin, v. 121 p. 265 – 277.

Lash, G.G., and Engelder, T., 2007, Jointing within the outer arc of a forebulge at the onset of the Alleghanian Orogeny: Journal of Structural Geology, v. 29, p. 774–786, doi: 10.1016/j.jsg.2006.12.002.

Lash, G.G., and Engelder, T., 2005, An analysis of horizontal microcracking during catagenesis: Example from the Catskill Delta Complex: American Association of Petroleum Geologists Bulletin, v. 89, p. 1433–1449.

Laubach, S. E., 1997, A method to detect natural fracture strike in sandstones: AAPG Bulletin, v. 81, p. 604– 623.

Laubach, S. E., 2003, Practical approaches to identifying sealed and open fractures: AAPG Bulletin, v. 87, no. 4, p. 561–579.

Laubach, S.E., Olson, J.E., and Gale, J.F.W., 2004, Are open fractures necessarily aligned with maximum horizontal stress? Earth & Planetary Science Letters, v. 222, no. 1, 191-195

Marrett, R., O. Ortega, and C. Kelsey, 1999, Extent of power-law scaling for natural fractures in rock: Geology, v. 27, no. 9, p. 799– 802.

Olson, J. E., 2004, Predicting fracture swarms—The influence of subcritical crack growth and the crack-tip process zone on joint spacing in rock, in J. W. Cosgrove and T. Engelder, eds., The initiation, propagation, and arrest of joints and other fractures: Geological Society (London) Special Publication 231, p. 73–87.