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Bedding-Parallel Natural Fractures: Their Occurrence in Shale Plays and Possible Effects on Hydraulic Fracture Treatments

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Abstract

Natural, bedding-parallel fractures are common in shale plays. Their occurrence has been linked to hydrocarbon generation or other fluid overpressure mechanisms, most convincingly where primary hydrocarbon fluid inclusions are trapped in the sealing cements of the fractures. The presence of sub-horizontal opening-mode fractures in reservoirs deep enough for hydrocarbon generation, where the maximum stress would be vertical, presents a geomechanical question. The simplest explanation for why the fractures are bedding-parallel and not vertical would be a tectonic shortening event, where horizontal stress could increase to overcome the vertical stress. In many basins, however, this is not the case, and horizontal fracturing appears to commence during the downward part of the basin burial history. In such situations other explanations are needed. One factor of high importance is strength anisotropy; shale is much weaker parallel to bedding than normal to bedding. This inherent weakness parallel to bedding is accentuated by the presence of fossils or layers with different mechanical properties. Indeed natural, bed-parallel fractures commonly utilize these entities for nucleation (Fig. 1), or repeatedly fail along the same planes with a crack-seal mechanism.

Figure 1. Bedding-parallel fracture with fibrous calcite (fcc) nucleating on fossil wood. Example from Haynesville Shale, East Texas (from Gale et al., 2014).

Most models of hydraulic fracture treatments show fractures growing vertically. The question posed by this paper is: do hydraulic fractures grow parallel to bedding, and if so, under what circumstances? My hypothesis is that they do, and that the relative stress magnitudes at the depth of hydrofracture generation, and strength anisotropy of the host rock are the key governing factors. Moreover, where natural fractures are present the strength anisotropy of the host rock is increased, making bedding-parallel growth more likely.

There are a few examples in the literature of microseismic monitoring studies of hydraulic fracture treatments that suggest horizontal growth. These have been where planes of events lie within bedding, or where fault-plane solutions can be calculated and indicate horizontal double-couple events (Figure 2).

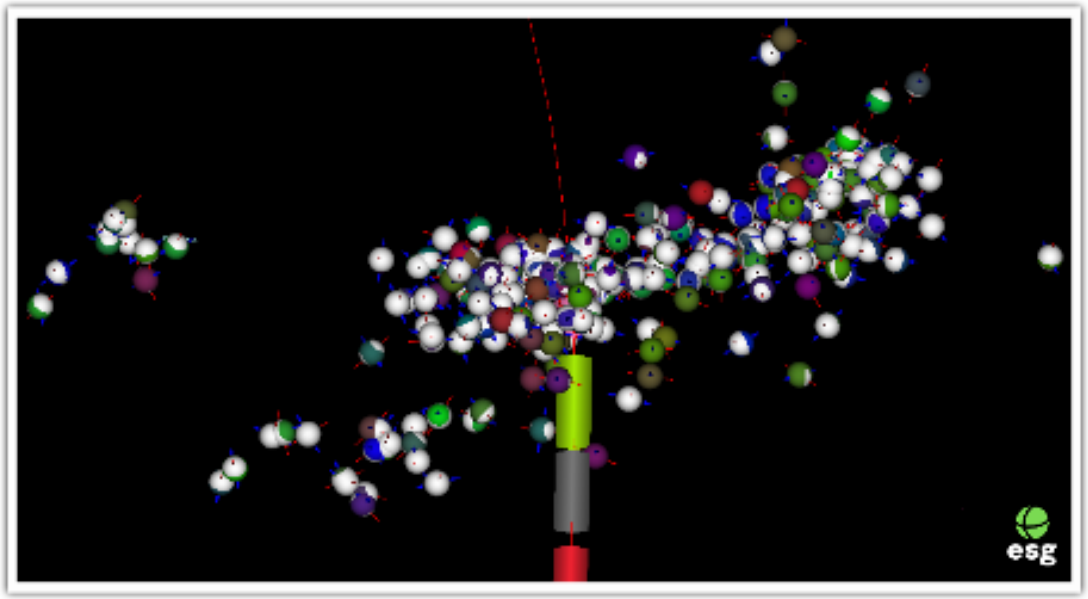

Figure 2. Example of horizontal fracture growth from ESG website page (ESG, 2014)

Understanding of when horizontal hydraulic fracture growth could be significant would be highly desirable in designing more successful hydraulic fracture treatments. We attempt to break this problem down into the components that need to be characterized to make an assessment for a specific case. The key components are:

1) The relative vertical and horizontal in-situ stress magnitudes (implicit in this is the depth of the treatment),
2) The strength anisotropy of the host rock (vertical versus bedding-parallel),
3) The occurrence and role of pre-existing weak planes in the form of sealed bedding-parallel natural fractures.

References

ESG 2014 website page https://www.esgsolutions.com/english/view.asp?x=858 Accessed August 26th 2014

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