EAGE

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Utilizing Moment Tensors to Identify Fracturing Behavior for Hydraulic Fracture Stimulations in Complex Geologic Domains

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SUMMARY

Microseismic monitoring has become an accepted method for monitoring fracture growth and stimulation effectiveness during hydraulic fracturing. In addition to delineating fracture dimensions and orientation, microseismic methods can also provide insight into local stress states adjacent to geological structures and their influence on fracture propagation. Understanding the role geology plays on fracture growth is integral to the planning and completion program of a hydraulic fracture treatment. In general, fractures will propagate in the direction of maximum horizontal stress which is controlled by the regional stress in the area. In contrast, we will show how local complex geologies can have a greater effect on fracture growth and fracture orientation as compared to a fracture network directly influenced by the regional stresses.

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In this study, we examine the microseismic results acquired during hydraulic fracture treatments in a shale play. The microseismic response illustrates the influence structures such as anticlines and dipping layers have on fracture growth, both in number of events as well as dimensions and types of fractures (Figure 1). We compare the differences in fracture dimensions, fracture intensity and microseismic response to injection parameters from treatments that targeted zones in varying geological structures. It will be shown how fractures activated during hydraulic fracture treatments traced the boundaries of the geological structures and conformed to the local stresses (Figure 2). Additionally, we look at events recorded using multiple downhole arrays of sensors, that allowed for the identification of fracture orientations, dimensions and mechanisms within a complex geological setting. We compare two event clusters within an stimulation; the first cluster located within the treatment zone and the second cluster grew vertically along the lithological boundary between two formations (Figure 2). The discrete fracture network calculated from the microseismic data identifies the fracturing response and how it was controlled by the local stress conditions and geologic structures, revealing the underlying changes that lead to differences in production. The cluster within the treatment zone yielded fracture orientations in line with the regional stress whereas the second cluster fractures conformed to the local bedding planes and folds of the anticlinal structure. A difference in source mechanism was also noted between the two clusters. Events that aligned with the geology also had a much larger shearing component compared to the in-zone fractures. Through detailed analysis of microseismic data, we can suggest that the role of local stress perturbations related to complexities in geology can have a definitive role in the observed fracturing. This can then lead to an understanding of whether the stimulation was contained within zone, what volumes were stimulated, and potentially the effectiveness of the stimulation leading to production.

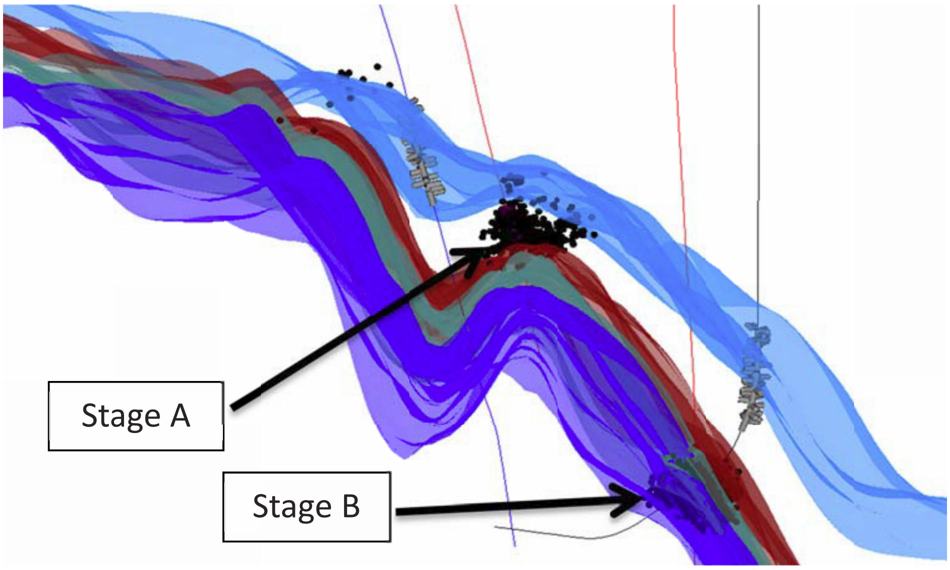

Figure 1: Example 1; Stage A treated a zone on the apex of a sharp anticline and Stage B treated a steeply dipping shale layer.

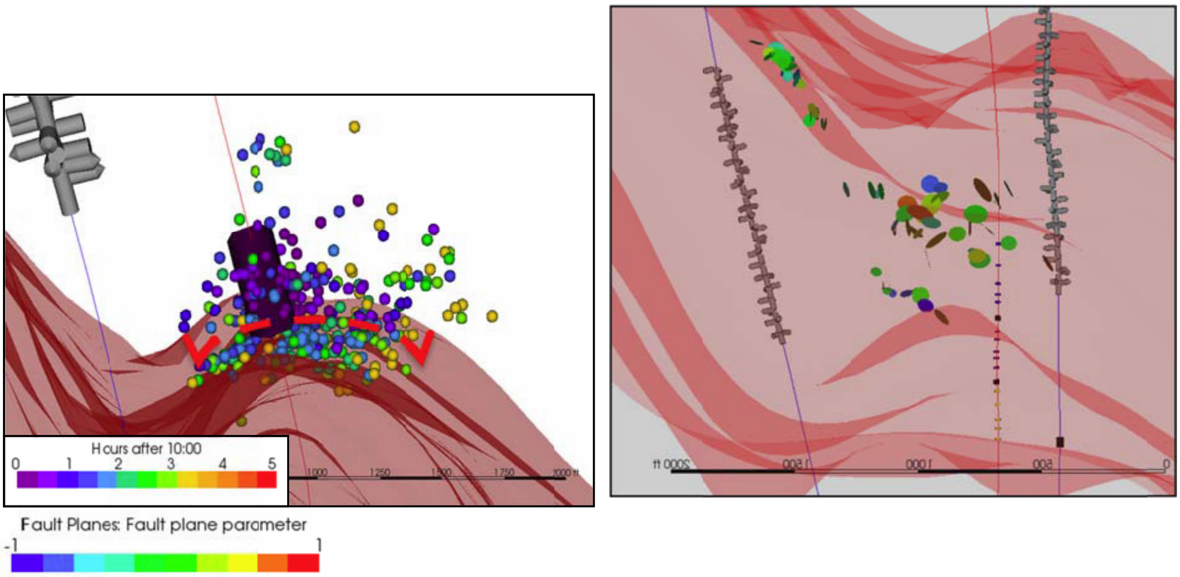

Figure 2: Example 1 (left), Stage A- scaled by elapsed time, view is parallel to hinge of anticline. Fracture growth initiates on zone and over time grows downwards and conforms to anticlinal structure. Example 2 (right); Differences in fracture orientation and mechanism illustrate the influence local stresses had on the fractures.