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Damage characterization due to microcracking near coalesced hydraulic fractures with acoustic emission

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ABSTRACT: Nanodarcy permeability is common in many oil- and gas-bearing unconventional formations requiring stimulation technologies, such as hydraulic fracturing, which can connect the isolated hydrocarbon-rich pores to a wellbore through induced fracture networks. Even though a dense induced fracture network is capable of accessing economic amounts of hydrocarbons, much of the rock between and very close to the fracture network is still un-accessed. Inducing fracture networks into rock can create large amounts of micro failures in surrounding regions that are not connected to the wellbore. Regions of rock containing microcracks near coalesced macro-scale fractures oftentimes behave differently than the original matrix material due to the permanent structural changes. These changes can manifest themselves in mechanical and petrophysical alterations from the original matrix conditions. Understanding that the coalesced fractures must drain the reservoir rock through these regions containing microcracks requires the characterization of damage within rock in terms of mechanical and petrophysical changes. In this study, a laboratory hydraulic fracture test was performed on a two-block system separated by a discontinuity as an analogue to a large natural fault. The induced hydraulic fracture was monitored with acoustic emissions (AE) throughout initiation, propagation, and interaction with the large fault. Individual AE event source characterization was performed to obtain mode of failure and relative volumetric deformation. Source characteristics were used in conjunction with cloud-based event density techniques to determine regions of differing damage within the cloud of microcracks. Quantitative three-dimensional event density imaging results were compared with permeability measurements on sub-cores taken from the sample post-test. Inverse relationship between AE event densities and permeability of sub-cores was observed, meaning that reductions in permeability were found nearest coalesced hydraulic fractures in the crystalline rock tested.

KEY WORDS: acoustic emission, laboratory, hydraulic fracture, microcrack, damage