Acoustic Emission Characteristics of Calcareous Source Rocks in Compression Tests

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ABSTRACT

Hydraulic fracturing (HF) and horizontal drilling are routinely used to improve the production of hydrocarbons from unconventional shale reservoirs. However, there is still an urgent need for an improved understanding of the fundamental rock and fluid physics in the source shale. While HF is well understood at a macro-scale, the physics at the micro-scale is still unclear, especially in source rocks. This paper experimentally investigates the characteristics of acoustic emissions (AE) induced in the calcareous source rocks subjected to externally applied stresses. The aim is to relate the AE event rate and characteristics to macroscopic observations of sample deformation, thereafter providing useful information on the macro-fracture mechanisms of unconventional shales. Source rocks are extremely heterogeneous in composition and structure at all scales, which leads to different mechanical and AE behavior from the homogenous sandstone. Our initial results displayed the distinct characteristics of AE events between Berea sandstone and unconventional shales. Discrepancy in AE activity was even observed among shale samples from various basins. This paper specifically focused on the calcareous source rocks. We perform compression tests along with AE measurement on outcrop and subsurface shale samples. Plugs are drilled adjacently from large samples in two orientations: parallel and perpendicular to the beddings. Prior to the testing, the high-resolution micro-CT scan is used for quality assessment of samples and characterization of microstructure and fracture presence. It is also used after testing to visualize the damage and microstructure variation. Ultrasonic measurements are conducted before and after the testing to quantify the effect of rock damage on the wave velocity. To find the most relevant parameters affecting the mechanical properties and AE of calcareous source rocks, XRD, SEM, and TOC measurements from the same samples were conducted. For source rocks, the complex mineralogical composition and heterogeneous microstructure (thin beddings and kerogen) played a significant role in the signature of AE events. Using the complementary advanced techniques (micro-CT, AE, Ultrasonic) enabled characterization of the stress-induced micro-crack development in unconventional shales. Such analysis could help understand and interpret seismic surveys and micro-seismic monitoring of hydraulic fracturing in unconventional reservoir exploration and development.