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Acoustic and microseismic emission monitoring of non-smooth fracture propagation using the Blue shift method

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Sequences of arrival times of acoustic or microseismic signals contain important information on the geometry of the cloud of the signal-producing defects/ microcracks. In particular, analysing the blue shift in the formal spectrum of arrival times it is possible to infer the power law of growth of the number of the signals with time. The integer part of its exponent (Blue Shift exponent) corresponds to the fracture propagation exponent, which is the exponent of the power law dependence of the number of newly produced defects/microcracks during the process of fracture propagation. This allows the determination of the type of the damage (process) zone formed at the propagating fracture contour, as well as the fracture propagation direction. The fractional part of the Blue Shift exponent corresponds to the fracture branching. The Blue Shift analysis of laboratory experiments on and field observations of hydraulic fracturing reveals that at the active stage of loading the fracture growth exponent equals 1. It turns to 0 in the shut-in phase. This suggests that the damage zone dimensions remain approximately constant during fracture propagation; and at the active stages of loading the hydraulic fracture grows in all directions in its plane (from all parts of the contour), while at shut-in the growth turns into unidirectional. In almost all cases the exponent was not integer, which indicates fracture branching. The PFC2D simulation of the uniaxial compression of a sample of particulate material shows that the Blue Shift determined exponent is not integer, which is consistent with branching observed in the simulation.