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Microseismicity Induced by Fluid Pressure Drop (Laboratory Study)

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Pore pressure change in saturated porous rocks may result in its fracturing (Maury et Fourmaintraux, 1993) and corresponding microseismic event occurrences. Microseismicity due to fluid injection is considered in numerous papers (Maxwell, 2010, Shapiro et al., 2005). Another type of the porous medium fracturing is related with rapid pore pressure drop at some boundary. The mechanism of such fracturing was considered by (Khristianovich, 1985) as a model of sudden coal blowing and by (Alidibirov, Panov, 1998) as a model of volcano eruptions. If the porous saturated medium has a boundary where it directly contacted with fluid under the high pressure (in a hydraulic fracture or in a borehole), and the pressure at that boundary is dropped, the conditions for tensile cracks can be achieved at some distance from the boundary.

In the paper, the results of experimental study of saturated porous sample fracturing due to pore pressure rapid drop are discussed. The samples (82 mm high, ∅60 mm) were made of quartz sand, which was cemented by "liquid glass" glue with mass fraction 1%. The sample (porosity 35%, uniaxial unconfined compression strength 2.5 MPa) was placed in a mould and saturated by oil. The upper end of the sample contacted with the mould upper lid, the lower end contacted with fluid. The fluid pressure was increased to 10 MPa and then discharged through the bottom nipple. The pressure increases/drops were repeated 30-50 times. Pore pressure and acoustic emission (AE) were registered by transducers mounted into upper and bottom lids of the mould.

It was found, that AE sources (corresponded to microfracturing) were spreading from the open end to the closed end of the sample, and that maximal number of AE events was registered at some distance from the opened end. The number of AE pulses increased with every next pressure drop, meanwhile the number of pulses with high amplitudes diminished. It was found that AE maximal rate corresponded to the fluid pressure gradient maximal values.

The model of AE relation with the pore pressure gradient was considered based on the following assumptions: AE event occurred when the pore pressure gradient reaches some critical value; the critical value varies and can be described by Weibull distribution.

Permeability variation during the fluid pressure drop was estimated by means of fluid pressure data and pore-elastic equation solution for small time intervals (0.01 sec). The study showed possibility to solve both a direct problem of microseismicity variation relation with fluid pressure changes and an inverse problem of defining permeability by registering microseismic activity variation in particular volume of porous medium alongside with pore pressure measurements at some point.