Laboratory study of hydraulic fracturing influenced by stress change

S.B.Turuntaev[1,2], E.V.Zenchenko, M.A.Trimonova[1], P.E.Zenchenko[1], N.A.Baryshnikov[1]

[1]*Institute of Geospere Dynamics of Russian Academy of Sciences, Moscow, Russia*

[2]*Moscow Institute of Physics and Technology (State University), Moscow, Russia*

The results of laboratory experimental study of the hydraulic fracturing are presented. The experimental setup differs from the usual equipment designed for testing cores or cubic samples and intended for experiments with samples of disk form, which allows to measure the pore pressure distribution along the sample together with acoustic emission (AE) and elastic wave velocities. The experiments were conducted on the artificial porous saturated samples made from gypsum/cement mixture in accordance with the similarity criteria. The samples had diameters of 430 mm and heights of 65 mm, they were saturated by gypsum water solution and loaded with vertical and two horizontal stresses. The hydraulic fractures were produced by mineral oil injection through a borehole under constant fluid rate. The fluid pressure was measured in the borehole as well as at several points in the sample bottom side.

To detect and record the fracture opening, ultrasonic pulses with a frequency of 250 kHz and a repetition period of 0.1 or 0.2 s were generated using piezoelectric elements located in the upper lid of the setup and recorded by sensors located in the lower lid. As a characteristic of elastic waves, which is influenced by the appearance of the fracture and the magnitude of its opening, the amplitude of the recorded pulses was used.

A set of experiments was conducted, in which the main stress axis orientation was changed after the first hydraulic fracture creation. Initially, the vertical stress was set minimal and the first fracturing was made. The obtained fracture had a horizontal section with a radius of 36 mm, but then it deviated from the horizontal propagation and reached the upper surface of the sample. After fixing the fracture position on the surface by disassembling the installation and photographing, the installation was reassembled, and a series of experiments were performed to inject fluid and relieve pressure at different values of vertical stresses in the range of 0.5 ... 2.5 MPa. Then a series of experiments were performed on the same sample, in which the vertical stress was much higher than the horizontal (6.9 MPa - vertical, 3.2 MPa and 0.95 MPa - horizontal). In these experiments, a vertical fracture was formed that crossed the previous horizontal one.

Registration of the change in the amplitude of the waves passing through the fracture made it possible to determine the moments of the fracture formations, the filling of the fractures with fluid, the increase in the fracture opening as the injection continued, and the fracture closing after the injection was stoped.

The obtained results can be used to better understand the mechanics of formation and development of hydraulic fracturing (including mini-fracturing), to verify numerical simulations and to adequately interpret field data.