Hydraulic fracturing and induced seismicity

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Hydraulic fracturing, carried out by pumping fluid into a given interval of a well under pressure exceeding rock strength and minimum stresses, remains the main method of increasing oil flow to the well. Despite a fairly long history of this method and the existence of a large number of design packages designed for the design of hydraulic fracturing (simulations of hydraulic fracturing), oil producing and oilfield service companies often face problems when conducting hydraulic fracturing, some of which are associated with insufficiently developed physical models software packages. The development and complication of these models requires the formulation of new experiments in the laboratory, allowing to evaluate the contribution of certain factors to the development of hydraulic fracturing.

A side effect of hydraulic fracturing is the appearance of seismic events induced by exposure to subsurface fluid systems. On the one hand, small magnitude events (microseismic events) are used as the main indicator of fracture propagation, its position, and geometric dimensions. On the other hand, in a number of areas of intensive development of fields and the massive use of hydraulic fracturing there has been a manifold increase in seismic activity and the appearance of noticeable earthquakes.

The report provides an overview of the data on seismicity of different levels recorded during hydraulic fracturing, the results of the analysis of seismic monitoring capabilities to determine the position of hydraulic fracturing, examines models of the occurrence of seismic events when pore pressure changes. The results of laboratory experiments on modeling of hydraulic fracturing in permeable environments under conditions of unequal stress state are given, the interaction of hydraulic fracturing fractures created in nearby wells is considered. A series of experiments on the creation of hydraulic fracturing with simultaneous recording of acoustic emission (analogous to seismic events in real conditions) and measuring changes in the parameters of acoustic pulses emitted at a given interval as it passes through the sample before and after the formation of cracks. It is shown that, depending on the ratio of the viscosities of the fracturing fluid and the formation fluid, one should expect different informativity of the microseismic monitoring and assume different scenarios for the development of seismicity. So, if the viscosity of the hydraulic fracturing fluid significantly (in laboratory experiments by two orders of magnitude) exceeds the viscosity of the reservoir fluid, the position of the hypocenters of microseismic emission pulses corresponds to the position of the hydraulic fracture. The possibilities of using rate-state friction models for estimating the magnitudes of possible seismic events are demonstrated.