Filtration in a medium with variable permeability

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To increase the efficiency of a production well, the method of hydraulic fracturing is used. For this purpose, a viscous liquid is injected into the well under high pressure. At the moment when the pressure of the fluid exceeds the strength of the rock, a crack occurs. Since the rocks have a porous structure and have some elasticity, it is possible to compress the skeleton of the behind-the-wall space during the development of a crack. A change in the structure of the porous mass entails a change in the permeability around the fracture. On the one hand, this affects the growth of the fracture, i.e., all the energy of the flow is directed to wedging the rock, and on the other hand, when oil is forced into the fracture, this worsens its seepage through the walls. In order to identify patterns of changes in permeability in the near-wall space on an experimental setup, a study was made of the effect of filtration on the stress-strain state of a poroelastic medium. The main part of the model setup consisted of a Hele-Shaw cell filled with a porous compressible material. A viscous liquid was pumped into the cell, the pressure of which was recorded at the inlet, and the process of changing the stressed-strain state was filmed on a video camera.

In the course of the study, it was noticed that the liquid, when entering a porous medium at high pressures, resembles a piston that compresses the porous medium, thereby reducing the permeability and reducing the speed of the filtration wave. Based on the results of the experiments, the propagation velocities of the front of the elastic wave, as well as the filtration wave, were determined. Using the data obtained, estimates of the change in the stress-strain state were carried out. The estimates obtained made it possible to calculate the permeability of the compressed region.

The research was carried out within the state assignment of Ministry of Science and Higher Education of the Russian Federation (theme No 122032900167-1).