Laboratory study of low-velocity flow nonlinearity in tight limestone rocks

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Many researchers note a decrease in the apparent permeability of rock samples at low flow rates. The effects include changes in apparent permeability with pore pressure gradient and so-called threshold gradients, below which low flow or no flow occurs. It is believed that these effects may be related to the influence of adhesive layers with altered properties at the interfaces between liquid and solid phases. Conventional methods for studying fluid flows in porous rocks are poorly suited for studying their permeability when approaching zero flow rates because of the lack of accuracy. Such studies also require a special approach to the interpretation of the data obtained. At the same time, there is a lack of discussion of the appropriate experimental technique in the publications known. Our goal was to develop a technique suitable for studying the transport properties of rock samples at extremely low flow rates. Using developed experimental technique, we carried out three series of consecutive tests on three similar limestone core samples. The samples were taken from the aquifer, however, their porosity and permeability are similar to the typical parameters of a tight oil reservoir. A steady flow technique was used, when the pore pressure gradient slowly decreased to zero. In each test, a relationship of effective permeability versus pressure gradient was obtained at flow rates of about 10e-6 m/s. During the test series, the change in the deviation from the linear Darcy's law was observed over a long time. We realized that in the sample with the most pronounced deviation from linear flow, there was a most significant decrease in net permeability in the entire series. We believe that there was a common reason for the permeability decrease and the filtration law deviation, and that reason could be related to the clogging of pores with gas.