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Comparative analysis of the reduction in permeability under loading in laboratory and field conditions

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The productivity of wells is influenced by the permeability of formations, which can decrease due to compaction caused by pressure drop. Accurately predicting permeability changes during hydrocarbon production is crucial for optimizing oil recovery and maintaining maximum productivity. However, despite the consensus among researchers that permeability changes follow a power law under loading, predicting permeability in field conditions is challenging. Coefficients of the power equation can differ significantly between comparative well tests and laboratory studies. Research indicates that rocks are more sensitive to a decrease in pore pressure under field conditions [1]. While the same trend may be observed in fractured rocks during laboratory studies, the cause of the large difference in permeability reduction in porous formations remains unclear. To investigate the mechanism of permeability decrease in porous rocks during field conditions, this study presents a comparative analysis of laboratory permeability tests on core samples and field tests on wells. The findings reveal that permeability decreases by over 95% under field conditions, whereas laboratory studies indicate a maximum decrease of only 20% under loading. The primary reason for this significant difference is the disparity in scale between the objects being examined. In core samples, even substantial loads result in purely elastic deformations with minor displacements [2]. However, at the reservoir scale, these same deformations can lead to displacements of several centimeters, causing the movement of rock blocks and the localization of deformation within bands [3]. Further studies have demonstrated that the degree of permeability reduction is linearly dependent on the thickness of the formation. A greater thickness of the formation results in the movement of more rock blocks, leading to the formation of a larger network of deformation bands that decrease well productivity. The research findings also indicate that this mechanism is characteristic of all kinds of porous formations, including terrigenous and carbonate formations.

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