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Steady and Unsteady Flow in Permeable-fractured Carbonate Reservoirs

L.C. Vasquez Cardenas* (National Mineral Resources University "University of Mines") & N.S. Golikov (National Mineral Resources University "University of Mines")

SUMMARY

This paper will discuss and suggest possible applications for the results of the aforementioned processes on a larger scale, utilizing systematical approaches with the scales of evaluation from core to reservoir, and adaptations for several hydrodynamic models. It also explains the impact of wettability and capillary forces during the drainage process between matrix and fractured structures. Furthermore, through the examination of pressure gradients, effective viscosities, and yield-shear stresses, a complete comprehension of reservoir dynamics will be greatly facilitated.

Introduction

The study of carbonate reservoirs rapidly expanded from the 1950s onwards and it is now believed that more than 60% of world oil reserves lie in carbonates. However, a large number of problems and challenges have arisen concerning the extraction of oil and gas from carbonates; this is due to carbonate's complex reservoir structures (matrix, fractured and fractal) and processes during flow, such as capillary and viscous forces. In addition to complicated flow dynamics, fractured reservoirs are quite intricate and difficult to recreate with the use of diverse models. Some carbonate reservoirs contain heavy oil and bitumen, which are lacking in suitable geological conditions for the production of oil, such as long high-permeability channels, fractures, low reservoir pressure, and/or temperature.

Method and/or Theory

Laboratory experiments were carried out using core samples of fractured-carbonate rocks (limestone) saturated with heavy oil (> 250 centipoise at 20°C) and then with brine, thus the core sample were saturated with oil to procedure with the drainage, during which tomographic scanners observed capillarity forces affecting the drainage process and low oil recovery under a steady and unsteady state flow rate; This process was repeated 2 times: 1st time to determinate changes in permeability under different flow rates (Figure 1), 2nd time imbibition and drainage of cores in the scanning. To determinate the position and “brine concentration by pore” of brine, to this a small concentration of KI (Potassium iodide) was added.

Figure 1 Differential pressure in several flow rates, also it is shown the measured permeability in that moment, There is clear that the permeability in several flow rates do not follow a lineal trend. The valour 25.09 is due the characteristics of oil (Non-Newtonian fluid).

Figure 2 Distribution along the cores samples and the respective oil saturation in that point. There is possible to see how with the increase of pore volumes through the oil saturation decrease, furthermore there are various zones where the saturation change slowly possibly due zones with low intercommunication. Zones 1.2 and 3 show a special behaviour possibly due fractures in the core sample or zones with big vugs. Zone 4 show the effect of capillarity on the drainage, this effect should be the same in the vugs.

Conclusions

Capillarity forces affects the drainage process and low oil recovery under a steady state flow rate; better results were obtained during unsteady state flow rates. Several segments along the core displayed an invariable character in their drainage due to the scale of evaluation; it therefore became evident that these segments are part of the matrix and the rest of the core is considered to be a fractured zone in interaction with this matrix.

We suggest possible applications for the results of the aforementioned processes on a larger scale, utilizing systematical approaches with the scales of evaluation from core to reservoir, and adaptations for several hydrodynamic models. Furthermore, through the examination of pressure gradients, effective viscosities, and yield-shear stresses, a complete comprehension of reservoir dynamics will be greatly facilitated.

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