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Plugging rules, macro-micro matching relationship and EOR mechanism of elastic particle: A microfluidic study

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The transport of elastic particles (EP) in porous media occurs extensively in groundwater filtration, fluidized beds, and oil field development. However, the pore-throat migration rules and the macro- and micro-matching relationship between EP and porous media require further study. In this work, four mechanism models were designed to conduct microfluidic injectivity experiments. By analyzing the pore throat flow behavior of EPs, their migration and plugging rules can be clarified. The microscopic matching characteristics of EPs and pore throats are evaluated based on their entry and retention status in throats of different sizes. Meanwhile, comparing the results of our previous macroscopic matching experiments can achieve the unification of macroscopic and microscopic matching between EPs and pore throats. In addition, microfluidic oil displacement experiments can be carried out based on the reservoir model, and the enhanced oil recovery (EOR) mechanism can be elucidated. The results show that EPs exhibit a "Gather-Energized" transport mode in porous media: as the injection pressure increases, EPs accumulate in the pores, then gradually enter the throat, and finally migrate away from the model outlet. The "Gather-Energized" transport mode and elastic deformation performance of EPs determine that they have the characteristics of pore-throat matching and preferential plugging of large pore-throats. According to the change in the pressure difference between the end time of EP injection and subsequent water injection, it can be determined that the upper limit of the microscopic matching factor is 1.3-1.4, and the optimal matching factor range is 0.8-1.0. The macro and micro matching relationship between EP and pore throats is highly consistent. After water flooding, EP can increase oil recovery by 6.95% compared to polymer flooding. The EOR mechanism mainly includes activating continuous remaining oil, increasing the injection-production pressure difference, and increasing the oil washing efficiency in the swept volume. The experimental results and conclusions of this work support the feasibility of using microfluidic experiments to replace complex core displacement experiments to evaluate the transport and matching characteristics of EPs.

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