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Pore-level observation of the transitional pore clogging by asphaltene deposition using micromodels

Monday, 31 May 2021 10:25 (15 minutes)

Asphaltene is defined as the crude oil component, which is soluble in toluene and insoluble in light-n-alkane [1,2]. In the development of oil fields, the deposition of precipitated asphaltene in a reservoir is a serious problem since it leads to clogging of the pores of the rock, resulting in a reduction in permeability [3]. Wang & Civan's model, which was constructed based on DBF (deep-bed-filtration) theory, has been commonly used in Darcy-scale simulations to calculate the volume of asphaltene deposition [4,5]. In this model, the deposition rate of asphaltene is expressed by the summation of three terms: surface deposition caused by adsorption or gravity sedimentation, entrainment, and clogging of pores. Each term contains an empirical coefficient that needs to be tuned by comparing the experimentally measured permeability and the calculated one [6], which means that these coefficients cannot be determined without experiment. Pore-scale observation of the deposited asphaltene can directly evaluate the types of deposition. The observation using X-ray microtomography showed that the cluster of deposited asphaltene clogged multiple pores after flooding with crude oil, which contains asphaltene, into a rock [7]. Although this shows the actual behaviour of the deposition, the transition of the clogging is still unknown. Several studies have been conducted with microfluidics experiments to capture the transient flow inside a transparent chip by a microscope. The process from precipitation to deposition of asphaltene at the wall of the chip [8] or dissolving behaviour of the asphaltene [9] have been visualised. However, the deposition process to clog the pores and the contribution of each type of deposition to the clogging is not well investigated.

In this study, the transition of asphaltene deposition inside porous media was visualised by a glass-made micromodel. In the micromodel, a lattice-like pore-network area with 6 cm in length and 1 cm in width was chemically etched. Each pore size was 100 μm in width and 110 μm in depth. Crude oil was mixed with n-heptane as a precipitant of the asphaltene and injected into the micromodel at a rate of 0.7 ml/h, which was equivalent to a Darcy velocity of 1.94× 10–4 m/s. During the injection, the area composed of 2.5 mm length and 1.8 mm width was monitored with a microscope with a ten magnification lens to obtain two-dimensional sequential images. Image analysis was conducted to identify deposited asphaltene.

We observed transitional processes from the deposition of asphaltene particles to the clogging of the pore spaces. At the initial stage, the deposition occurred at the local site of the pores. The deposited site grew by the accumulation. Finally, these local clusters were connected, resulting in the complete clogging of the area. The area of occupancy of the pores clogged with asphaltene linearly increased to 57.6%.
The ratio of deposition type to total deposition area was evaluated quantitatively to investigate each type's contribution to the permeability reduction.

Time Block Preference

Time Block A (09:00-12:00 CET)

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