Pore-scale imaging of asphaltene deposition with permeability reduction and wettability alteration

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Introduction

- The precipitation of asphaltene from crude oil causes clogging in pore network and fractures, resulting in a reduction of permeability.
- The reservoir wettability changes after asphaltene precipitation.
- The novel in-situ pore-scale scanning in this research

Methodology

Micro-CT scanning
- Step 2: Doped-brine saturated condition
- Step 3: 1st drainage (by doped-heptane)
- Step 4: 1st waterflood (by brine)
- Step 5: 2nd drainage (by pure heptane)
- Step 6: Crude oil and heptane mixture injection for asphaltene precipitation
- Step 7: Only pure heptane injection
- Step 8: Asphaltene displacement
- Step 9: 2nd waterflood (by doped-brine)  

Results: pressure recordings

Example of brine/heptane curvatures on 2D image slices before and after asphaltene precipitation: (left) positive curvature indicating water-wet conditions, A; (right) negative, B, and zero, C, curvatures indicating oil-wet or mixed-wet conditions. Blue is brine, yellow is heptane, and black is solid rock or asphaltene.

Conclusions

- Asphaltene deposition has been observed in situ in high resolution.
- Asphaltene deposition largely dropped the permeability (90 times dropped from step 4 to step 9).
- Asphaltene deposition changed the rock wettability (confirmed from both curvature and contact angle analysis).
- More asphaltene deposited at the inlet area, with gradient for asphaltene fraction along the flow direction.