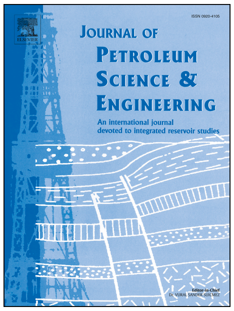

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Pore-Scale Mechanisms during Low Salinity Waterflooding: Oil Mobilization by Diffusion and Osmosis

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Abstract

Pore-level oil mobilization is studied during low salinity waterflooding by microscopic visualization of water diffusion and osmosis in sandstone silicon-wafer micromodels. The two-dimensional water-wet micromodels apply a controlled, state-of-the-art experimental approach, with a high accuracy pore network, sharp edges and surface roughness to observe transport and displacement processes during low salinity waterflooding. Residual and capillary trapped oil is mobilized when a salinity contrast is established between high-saline connate brine in matrix and low salinity water flowing in an adjacent fracture. The driving force is the difference in chemical potential between the aqueous phases. The focus of this work is on water transport by diffusion and osmosis, mechanisms that are both present in low salinity waterflooding, but less reported in literature. The micromodel system makes it possible to distinguish diffusive and osmotic effects from other well-known mechanisms such as wettability change and fines migration. Transport of water occurs by diffusion through film-flow resulting in film-expansion along water-wet grains. In presence of an osmotic gradient the oil-phase act as a semi-permeable membrane allowing transport of low salinity water into high-saline water-in-oil emulsions.

Keywords

Low salinity effect; Pore-scale mechanisms; Osmosis and Water Diffusion; Oil mobilization; Salinity contrast; Chemical potential

1. Introduction

Whereas conventional waterflooding uses formation brine or seawater to maintain reservoir pressure, there is a growing interest in applying low salinity waterflooding (LSW) as a tertiary oil recovery method to improve sweep efficiency by injecting water with diluted salt concentration (Morrow and Buckley 2011). Coreflood data reported in literature show an additional increase in recovery ranging from 4-19% OOIP by injecting diluted brines (Pu *et al.* 2010; Tang and Morrow 1999; Yousef *et al.* 2011; Zhang *et al.* 2007). A general assumption is that LSW, preferably below 4000ppm (Webb *et al.* 2008), shifts reservoir wettability from mixed-wet towards more water-wet conditions improving microscopic displacement and reducing residual oil saturations (Kasmaei and Rao 2015).

Improved oil recovery (IOR) by LSW came into focus by the laboratory work of Tang and Morrow (1997). Working under the assumption that initial wettability was influenced by a salinity contrast between injection-water and connate brine, they performed a series of coreflood experiments studying the release and movement of mixed-wet fines and clay particles. During LSW, wettability alteration is generally detected through indirect changes in relative permeability and capillary pressure curves (Morrow and Buckley 2011). A decrease in permeability and increase in pressure-drop indicate that the released particles improve microscopic sweep by blocking pore throats and diverting flow into un-swept areas (Morrow and Buckley 2011; Tang and Morrow 1999). It has, however, been argued that the described mechanisms are more