FE-BEARING CLAY MINERALS AND FE$_{STR}$ REDUCTION IMPLICATION ON OIL ADSORPTION.

N. Apeiranthitis$^1$, H. C. Greenwell$^1$, A. Neumann$^2$, C. Carteret$^3$

$^1$Durham University, UK, $^2$Newcastle University, UK, $^3$Lorraine University, France

Introduction

The nature of the rock/oil/water interface exerts a significant influence on enhanced oil recovery (EOR), as it is the controlling factor for more incremental oil to be released. Focusing on low-salinity water flooding, which was identified in laboratory experiments and implemented in small field-scale trials, is an enhanced oil recovery method with potential to contribute towards further oil production during secondary and/or tertiary recovery of a conventional oil reservoir, (Fjelde et al., 2013). The main intervention of this particular EOR method is to reduce the salinity of the water injected into the reservoir to expel the oil, as this water has lower salinity than that originally in the reservoir. As such, the equilibrium in the rock/oil/brine system will be changed. In order for this EOR method to be successful, some initial conditions should be met, such as the connate water containing divalent cations, the presence of clay minerals, and the presence of acidic and basic oil molecules in the crude oil. Numerous mechanisms have been postulated to describe this EOR method, with the most significant ones being: clay swelling and fines migration, pH increase and interfacial tension (IFT) reduction, multi-ion exchange and double layer expansion. In many cases the result of these processes results in a wettability change from, the ideal in that EOR method, mixed-wet towards more water-wet conditions (Jackson et al., 2016).

One factor that has hitherto been little examined is how structural iron (Fe) in clay minerals can affect their wettability in relation to the reduction-oxidation state of the reservoir. The reservoir initially will invariably be in a reduced state, until flooded and any different water injected can potentially turn this to an oxidizing state. (Wang and Guidry, 1994) observed, in core plug experiments, less oil adsorption after reduction of Fe$^{3+}$. A key question is how Fe reduction and the net negative surface charges (Stucki et al., 1984a, Stucki et al., 1984b) affects the different cation affinity on the clay sheet surface with respect to its hydration energy and consequently the oil adsorption onto these surfaces. By describing better how clay minerals behave both in oxidized and reduced conditions, in terms of swelling, cations exchange and oil adsorption, a better comparison and understanding of the underpinning mechanism(s) during low-salinity water flooding will be achieved.

Experiments

Ferruginous clay minerals are supplied from CMS repository, USA. Tow nontronites (NAu-1, NAu-2), one illite (IMt-2) and one Na-Montmorillonite (SWy-3). Three studies will be conducted using these clay minerals:

- Contact angle measurements on clay films, using crude oil, under oxidised and reduced conditions.
- Cation exchange series under reduced conditions.
- Infrared Spectroscopy (FTIR) studies of hydration (wetting) under oxidised and reduced environments.

For the first set of experiments, untreated clay minerals are already used to produce clay films under oxidised conditions and contact angle measurements are taken. While for the reduced conditions, oxidised clay films will be reduced in sodium dithionite solution and then used for the same kind of measurements.
For the second set of experiments, pre-saturated clay minerals are used to establish the cation selectivity between Na, K and Ca.

And for the third set, the pre-saturated clay minerals are aged with model oil (carboxylates) and then the oil adsorption is examined for differences due to Na, K or Ca presence, both in reduced and oxidised conditions. Along with the reduced part of these experiments, the different cation hydration is examined.

References


