Experimental report

06/07/2022

Proposal: **1-05-27**

Council: 4/2020

Title: Investigate the multi-phase flow in porous media using neutron imaging

Research area: Chemistry

This proposal is a new proposal

Main proposer: **Shirin ALEXANDER**

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Samples: rocks
Surfactant- iC18S(FO-180)
Aluminium oxide nanoparticles

Instrument	Requested days	Allocated days	From	To
NEXT	5	3	24/06/2021	27/06/2021

Abstract:

Understanding how the structure of reservoir rocks affects fluid flows is a significant factor in dealing with resource engineering challenges; such as CO2 sequestration and hydrocarbon production. Traditionally, X-ray imaging has been applied to visualize porosity and equilibrium fluid distributions in porous materials. This proposal looks at the unique advantages of neutron imaging compare to X-ray imaging for investigating fluids flow in abiotic non-hydrogenous porous media. The advantages of these visualization techniques are that they are non-destructive and give an insight into the rock which would be otherwise impossible. This work focuses on achieving quantitative understanding of how nanofluids behave and change (local and global) permeability in (sandstone and carbonate) reservoir rocks under different environmental condition.

1 PRINCIPAL INVESTIGATOR
Name and institution of the Principal Investigator
Dr Shirin Alexander College of Engineering Swansea University UNITED KINGDOM

2 EXPERIMENT DETAILS	
Experiment RB No: 1-05-27	
Title: Investigate the multi-phase flow in porous media using neutron imaging	
Instrument: NEXT	
Dates scheduled: 24th of June 2021	No. Days allocated: 3 days
Date of experimental report: 4th July 2022	

3 EXPERIMENT OBJECTIVES
These can be taken from the abstract of the original proposal.

Understanding how the structure of reservoir rocks affects fluid flows is a significant factor in dealing with resource engineering challenges, such as for example CO_2 sequestration and hydrocarbon production. Traditionally, x-ray imaging has been applied to visualize porosity and equilibrium fluid distributions in porous materials. This proposal looks at the unique advantages of neutron imaging compared to (X-ray imaging) for investigating hydrogen fluids in abiotic non-hydrogenous at porous media. The advantages of these visualization techniques are that they are non-destructive and give an insight into the rock which would be otherwise impossible. This work focuses on achieving quantitative understanding of how nanofluids behave and can change (local and global) permeability in (sandstone and carbonate) reservoir rocks from nanofluid injections under different environmental conditions

4 EXPERIMENT REPORT

Solution preparations:

Each sample solution was prepared first making surfactant solutions at CMC using 50 mL D_2O (taking into account the density of heavy water) by stirring for 24 h to reach equilibrium. Then 0.5 wt.% of each of the nanoparticle (MEEA-NP and OCT-NP) added into surfactant solution and left stirring for anther 24 hour to create a homogenous suspension.

Reservoir rock cleaning and setup:

The reservoir rocks were cleaned via Soxhlet extraction using toluene for two weeks to remove all organic compounds. The rock samples then dried at 60 °C in air oven. The samples were further cleaned by Deionized water to remove salt twice daily, and at each time tested for the presence of salts with an aqueous solution made of (1 mM of $AgNO_3$ dissolved in deionized water). After removing all ions/salts from reservoir rock, it is then dried with air oven at 60 °C for 7 h.

At the beginning of each test, dry reservoir rock scanned with neutron, and scanned while injected with brine solution (1 wt.% NaCl dissolve in D_2O).

Six reservoir rocks with “2 and 2.5 inch” diameter and height respectively. The system variables were two functionalized nanoparticles (hydrophilic and hydrophobic) and low surface energy surfactant which has been used to be able to disperse the hydrophobic nanoparticles in D_2O. The functionalized nanoparticles were synthesis to observed effect on microstructure of reservoir rock. The experiment run by using an aluminium cup (manufacture by user) and shrinking tube. Each rock had been scanned at one single time. The effect of salt (1 wt.% of NaCl) had been investigated as well.

Figure 1 showed the preparation set up, (a: reservoir rock, middle, b: reservoir rock with aluminium cups attached (ready for scanning), c: complete set up).

Figure 2, a 2D model for dry reservoir rock (a) and saturation rock with 1 wt% of NaCl (b). As is clearly seen in the Figure that the intensity between dry and saturated rock is different. Following Figure 2 (c), show the 2D reconstructed images of saturated reservoir rock by hydrophilic nanoparticle (c-left), and hydrophobic nanoparticles (c-right). As can be seen, it is difficult to differentiate between both nanoparticles. It suggested that both nanoparticles scattering density are similar. The dry rock has been analysis by AVIZO software, the total porosity for area (230, 521, 241) is shows in figure. The segmentation of all rock area is ongoing.

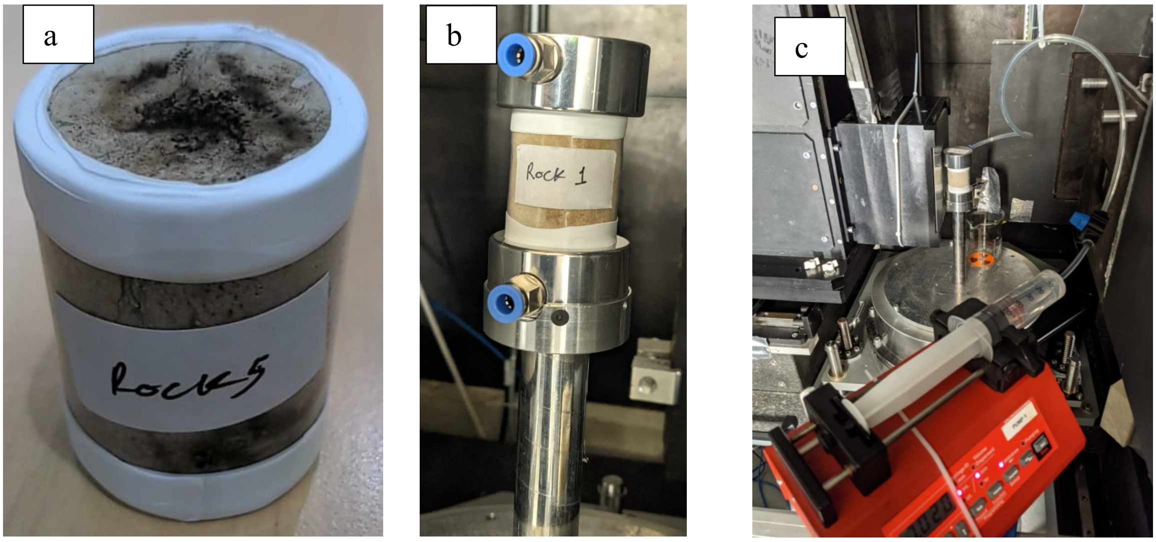

Figure 1: a: reservoir rock, middle, b: reservoir rock with aluminium cups attached (ready for scanning), c: complete set up.

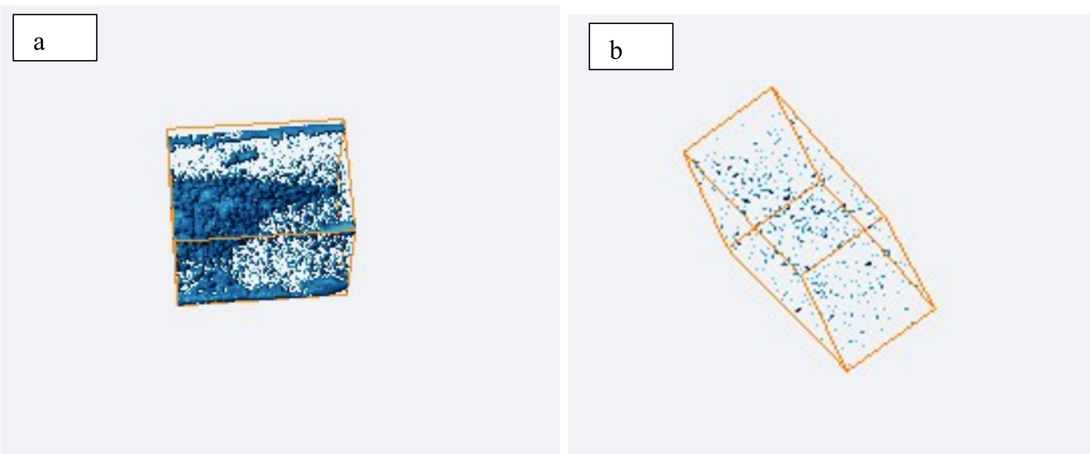

Figure 1: Porosity distributions for: a) dry rock and b) after saturation with 1 wt% of NaCl.

Regards to COVID19 retraction we were unable to come to ILL and run our samples. The cleaning had been done in Swansea University ESRI laboratory. We aim to develop an aluminium holder and do in-situ scan for better understanding the effect of nanoparticles addition in microstructure of reservoir rock.