A Microfluidic platform combined with Confocal Raman Imaging to study Enhanced Oil Recovery

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OBJECTIVE

Injection of Low Salinity Water for enhanced oil recovery (EOR) is a novel technology. However, previous studies aiming to understand the mechanism responsible for this enhancement lack in two domains :

a) A microfluidic environment mimicking the pore geometry of the rocks and
b) Chemical specificity for quantitatively determining the distribution of the components involved in the process.

We aim to provide a microfluidic platform in combination with confocal Raman imaging for probing the mechanisms responsible for EOR.

EXPERIMENTAL SETUP

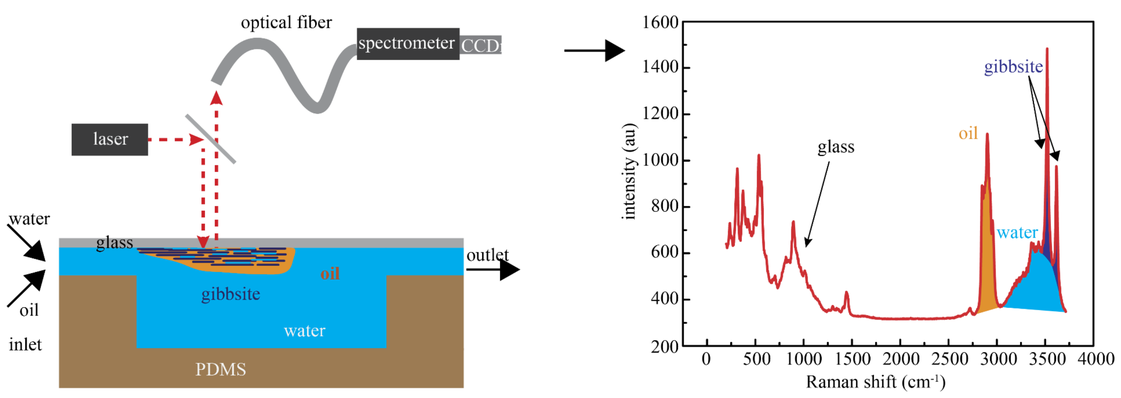


Figure 1 : Microfluidic platform and corresponding Raman spectrum showing the efficiency in identifying all the components.

- Substrate – Quartz + Gibbsite (clay facet) deposit.
- Defending liquid – Mineral Oil + 1 mM Stearic acid.
- Invading liquid – 10 mM $CaCl_2$ vs deionized water.

FLUSHING PROTOCOL

- Raman maps (3D) over 30 µm depths are made at steps 4 and 5.
- Gibbsite, oil and water distributions are mapped and compared for both saline and DI water flushing.

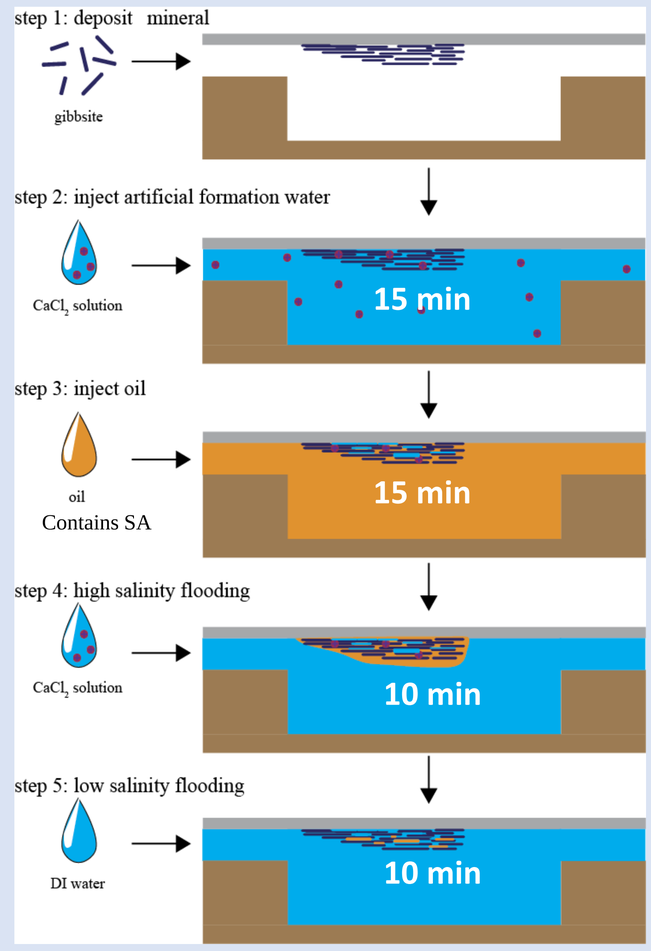


Figure 2 : Flushing protocol for the study.

WHAT WE LEARNED

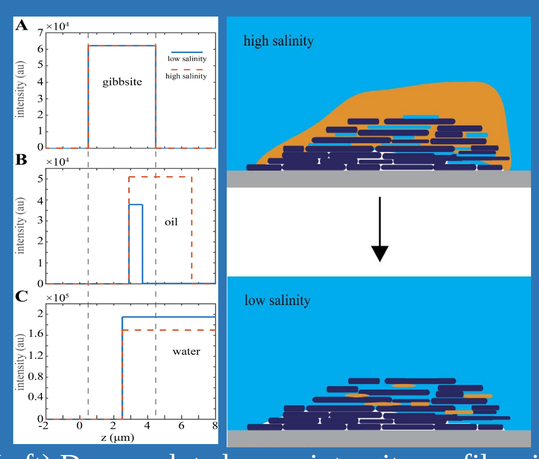
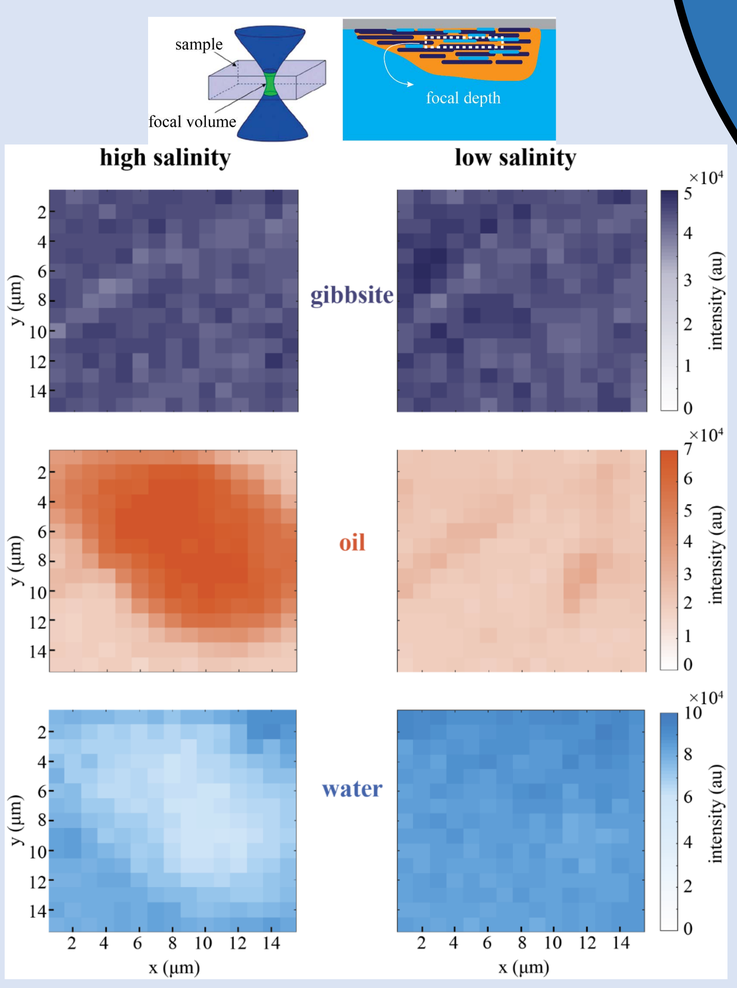


Figure 5 : (Left) Deconvoluted mean intensity profile with depth for Gibbsite, oil and water and (Right) Schematic of the process, deduced from the Raman maps.

The study validates the effect of divalent cations in bridging organics in oil to the mineral surface and how this oil can be removed by injecting a salt-free water, which disrupts these bridges.

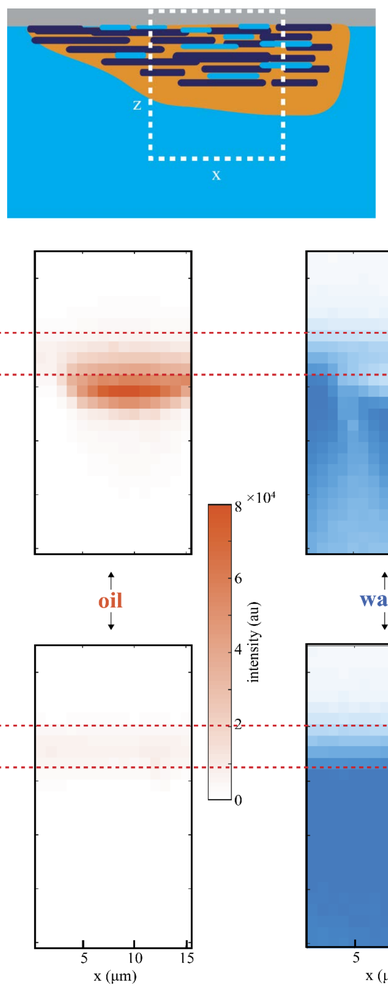
RESULTS: XY RAMAN MAPS



- ✓ Gibbsite is stable to DI water flushing.
- ✓ Oil intensity drops – indicating low adhesion of oil to Gibbsite in the case of DI water flush.
- ✓ Water intensity increases – replaces oil.

Figure 3 : XY Raman maps comparing the distribution of components in response to saline and DI water flushing.

RESULTS: XZ RAMAN MAPS



- ✓ Oil adsorbs both inside and outside the Gibbsite deposit.
- ✓ Water penetrates through the structure to displace oil.

Figure 4 : XZ Raman maps comparing the distribution of components in response to saline and DI water flushing.

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