

Monitoring Salt Precipitation in Porous Media Using ^{23}Na MRI

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Introduction: Salt precipitation, also known as salt-out poses a challenge for CO_2 storage in saline aquifers, due to potential injectivity loss. While ^1H MR/MRI has been used to monitor water evaporation [1], ^{23}Na MR/MRI offers additional insight by enabling the tracking of sodium in both dissolved and crystalline forms. Furthermore, ^{23}Na MR/MRI can be combined with ^1H MR to give sodium concentration in the brine phase.

Methods: Experiments were conducted on Bentheimer sandstones saturated with 8 wt% NaCl brine, with dry N_2 as a model gas. Salt precipitation was monitored using a variable field magnet allowing to switch between ^1H and ^{23}Na MR measurements. The ^{23}Na MR signal was resolved using both T_2^* and T_1 relaxation times, enabling quantitative differentiation of sodium content in solution and solid phases. Phase-encode imaging methods were employed to selectively image solution and crystalline sodium.

Results and discussion: Initially, brine was displaced due to viscous flow of gas. Fluid displacement was well separated from the subsequent evaporation and salt precipitation stages. A complete conversion of the residual solution sodium into crystalline sodium was observed. 1D and 2D images were acquired showing the spatial distribution of sodium during and after drying.

Conclusions: Crystallization was localized at the drying front near the sample inlet. This salt accumulation was attributed to capillary backflow [2] to transport sodium to the drying front, as evidenced by the contrasting spatial profiles of ^{23}Na and ^1H content in solution. The methods presented using ^{23}Na MRI have great potential for salt precipitation studies, paving the way for applications in CO_2 storage and other processes.

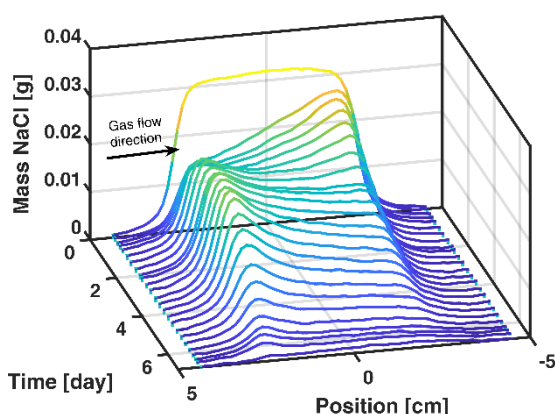


Fig. 1: 1D Hybrid-SESPI images of solution, ^{23}Na converted to NaCl mass for display.

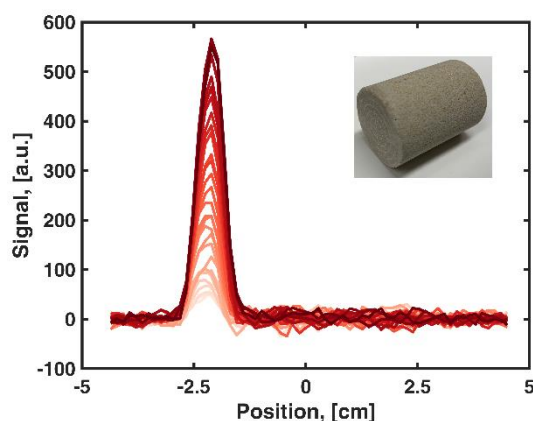


Fig.2: 1D images of crystalline sodium at various times during the process acquired using 1D DHK SPRITE. The images show progressive accumulation of salt crystals at the entrance of the core plug.

References:

- [1] Y. Wang, E. Mackie, J. Rohan, T. Luce, R. Knabe, and M. Appel, SCA2009-25 (2009)
- [2] H. Ott, S.M. Roels, K. de Kloe, Int. J. Greenh. Gas Con. 43, 247-255 (2015)