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In situ observation of the crystallization pressure induced by halite crystal growth in a microfluidic channel

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Abstract

Halite crystal growth was conducted within a polydimethylsiloxane (PDMS) microfluidic device to understand the mineral deposition behavior in a confined environment as well as the properties and evolution of the crystallization pressure. Supersaturation was induced by cooling a NaCl solution from 35 to 25 °C, and time-lapse images of halite crystal growth in the PDMS channel were collected. Halite crystal growth caused the PDMS to deform when the crystal faces reached the PDMS channel walls. The interface between the halite crystal and the channel wall changed over time and showed non-equilibrium behavior. Deformation of the PDMS wall was evident from the photoelastic effect within the PDMS material. The crystallization pressure in the laboratory experiments was quantitatively evaluated through numerical models of microscopic PDMS deformation due to halite crystal growth. Halite indentation observed in the laboratory experiments was reproduced in the model based on the retardance observed by the photoelastic effects of the PDMS. The crystallization pressure, defined as the normal stress acting to the PDMS wall surface from the halite crystal, was inhomogeneously distributed along the interface, with a maximum value of 2.0 MPa at the crystal corner. PDMS microfluidic devices are useful for understanding the behavior of mineral precipitation in confined environments. Deformation analysis of the photoelastic stress, along with numerical modeling, may be used to examine the nature of the crystallization pressure and to shed light on the mechanism of deformation due to the crystallization pressure.

Keywords: Crystallization pressure, halite, PDMS, photoelastic effect