Dissolution variability of sandstone calcite cement

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Kinetic quantification of solid-fluid interactions is crucial for the upscaling and prediction of natural and industrial processes. Of special interest is the process of dissolution and the understanding of its surface-controlled mechanisms. Vertical scanning interferometry (VSI) allows for the calculation of spatially resolved dissolution rate maps (units in $mol.m^{-2}.s^{-1}$), as well as the integrated surface normal retreat (units in $mol.s^{-1}$), of several square millimeters and nanometer height resolution. These features make VSI one of the most promising process upscaling techniques.

A sandstone reservoir-type rock bearing pure calcite ($CaCO_3$) cement was chosen for this study. The rock was cut and polished before reaction in a flow-through cell using a 2 mmol Na_2CO_3 solution (pH 8.6), at different reaction times (3, 6, 9, 12, 18, 24, 32 hours). The experiments were carried out at surface-controlled conditions. No precipitation products were found. The dissolution rates were calculated from topography maps obtained using VSI.

The results suggest that there is a direct correlation between dissolution rates and specific surface morphologies. Several statistical parameters were used to characterize the distribution of rates, including an innovative approach to extract the maximum rates (rate spectra tail) typically related to the appearance of higher reactivity areas, such as etch pits. Moreover, a correlation between integrated surface normal retreat (total material flux) and the calcite cement grain sizes was obtained.

This study provides new methodologies for data treatment and analysis of the variability of dissolution rates that may ultimately lead us to an improved theory of mineral dissolution.