American Mineralogist, Volume 97, pages 480–483, 2012

LETTER

Morphological quantification of hierarchical geomaterials by X-ray nano-CT bridges the gap from nano to micro length scales

SEBASTIEN BRISARD,[1] ROSIE S. CHAE,[2] ISABELLE BIHANNIC,[3] LAURENT MICHOT,[3] PETER GUTTMANN,[4] JÜRGEN THIEME,[5] GERD SCHNEIDER,[4] PAULO J.M. MONTEIRO,[2] AND PIERRE LEVITZ[6,*]

[1]IFSTTAR, Dept MACS, 58 Boulevard Lefebvre, F-75732 Paris, France
[2]Department of Civil and Environmental Engineering, University of California, Berkeley, California 94720, U.S.A.
[3]Laboratoire Environnement et Minéralurgie, CNRS-Nancy University, F-54501 Vandoeuvre, France
[4]Helmholtz-Zentrum für Materialen und Energie GmbH, electron storage ring BESSY II, Albert-Einstein-Str. 15, 12489 Berlin, Germany
[5]Brookhaven National Laboratory, Upton, New York 11973, U.S.A
[6]Université Pierre et Marie Curie, CNRS, Laboratory PECSA, 4 place Jussieu, F-75252 Paris, France

ABSTRACT

Morphological quantification of the complex structure of hierarchical geomaterials is of great relevance for Earth science and environmental engineering, among others. To date, methods that quantify the 3D morphology on length scales ranging from a few tens of nanometers to several hundred nanometers have had limited success. We demonstrate, for the first time, that it is possible to go beyond visualization and to extract quantitative morphological information from X-ray images in the aforementioned length scales. As examples, two different hierarchical geomaterials exhibiting complex porous structures ranging from nanometer to macroscopic scale are studied: a flocculated clay water suspension and two hydrated cement pastes. We show that from a single projection image it is possible to perform a direct computation of the ultra-small angle-scattering spectra. The predictions matched very well the experimental data obtained by the best ultra-small angle-scattering experimental setups as observed for the cement paste. In this context, we demonstrate that the structure of flocculated clay suspension exhibit two well-distinct regimes of aggregation, a dense mass fractal aggregation at short distance and a more open structure at large distance, which can be generated by a 3D reaction limited cluster-cluster aggregation process. For the first time, a high-resolution 3D image of fibrillar cement paste cluster was obtained from limited angle nanotomography.

Keywords: New technique, X-ray nanotomography, clay suspension, cement pastes