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Small- and Ultrasmall-Angle Neutron Scattering as a Tool for Characterization of Geological Structures and Biomineralization Processes

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Small- and Ultrasmall-Angle Neutron Scattering, or (U)SANS is a powerful tool for the characterization of the structure and porosity of geological structures and in materials created by biomineralization processes, providing complementary information to that available through BET, microscopy techniques, and related x-ray techniques. There are three key reasons to consider using neutron scattering methods: sensitivity to light elements, isotopic sensitivity, and the high penetration with low energy deposition of neutrons in most materials. Neutrons have a high scattering cross-section for hydrogen, with the two most common, non-radioactive isotopes—protium and deuterium—having scattering lengths with opposite sign, allowing for contrast variation studies using natural and deuterium-enriched fluids. The high penetration of neutrons in most materials means that neutrons can be used to study samples in complicated or bulky sample environments, such as furnaces, pressure cells, shear and compression, and reaction cells. Furthermore, the inelastic incoherent scattering of protium (the majority isotope of natural hydrogen) allows the changes in bulk hydrogen content of a sample to be quantitatively tracked during processing. The benefits and limitations of contrast-variation studies of fluid intrusion to probe pore networks and connectivity in geological formations and materials produced by biomineralization processes will be discussed, and applications of (U)SANS to probe modification to these materials from in-situ and ex-situ processing will be presented.

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