3D structures of biomineral architectures by new X-ray imaging techniques

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The complex structures of geological or biogenic mineral architectures are most often structured over several lengthscale from the nano- to mili-meter. Due to their complex architectures, there is a burning need for improved methods that allow unravelling their structures and composition in three dimension. Improvements in synchrotron technogogies now enable such methods.

The mesoscale structure of biominerals can be uncovered by using various tomography techniques. These include holotomography [1] and ptychography [2]. Importantly, these techniques allow quantitatively determining the electron density in the material. I will discuss our application of these techniques to sub-100 nm resolution 3D imaging of glass spicules from the sponge *Euplectella aspergillum* [3] and to bone.

The imaging techniques described above allow excellent insights into biomineral architecture but not into their composition. This can however be obtained through the use of other tomographic techniques such as diffraction scattering computed tomography [4,5,6] or fluorescence tomography [7]. In the latter, X-ray fluorescence is measured as a function of position and angle across the specimen and tomographically reconstructed to yield maps of element distributions within the specimen. We used fluorescence tomography on bone and obtain element maps with a little better than 100 nm resolution for the first time for an optically dense material. The data easily allow mapping osteocyte canalicular porosity in e.g. the Ca-fluorescence signal. The results illustrate the immense promise of such techniques for investigating complex biominerals but also more generally for unravelling mineral architecture and chemistry.

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