

Ultrahigh resolution, 3D images of diatoms: CT scanning at submicrometre scale

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Diatoms are single cell, microplanktonic algae that create amorphous, colloidal silica shells. They are present in oceans, lakes, rivers, ponds and on glaciers, are responsible for at least 25 % of the oxygen production on Earth and are the base of the food chain in aquatic systems. Better understanding of their life cycle would contribute directly to ecological studies, provide data for global element cycling and offer deeper understanding of the mechanisms by which they sequester Si, even from very undersaturated solutions. Deeper insight into the mechanisms of cell wall silicification would offer clues for creating organic compounds to enhance amorphous silica precipitation and contribute to improved design of functional materials. Current study of diatoms mainly uses light microscopy, which shows the internal structure of the cells and the external features that are used to classify them. However, light microscopy projects the entire content of the cell onto a plane. By changing focus, one is able, to some extent, to see details within the cell but quantification of features in a third dimension is difficult to impossible.

3D X-ray microscopy, known from CT scanning at hospital scale, has been developed in our research section, to scan organisms, in solution, at submicrometre scale. This new instrument and tomographic reconstruction software offer views of internal and external structure of diatoms, in 3D, where quantification is possible. We investigated diatoms from two locations in the alkaline lake, Mývatn, in northeast Iceland, from a cold spring (~9 °C) and a warm spring (~17 °C). The diatom samples were scanned fresh and during decomposition, which contributed uncertainty, quantified by the contrast to noise ratio (CNR). Sample preparation and cell viability were important parameters for scan quality, with sediment particles and decomposition reducing CNR. X-ray microscopy was previously demonstrated useful for in situ studies of fracture minerals [1]. This current work demonstrates its potential for even higher resolution studies, in solution, of organisms that play a role in geochemical systems.

[1] Sørensen H.O. et al. (2012) Nondestructive identification of micrometre scale minerals and their position within a bulk sample. *Canad. Mineral.* 50, 501-509; DOI:10.3749/canmin.50.2.501