Chapter 2
Chemistry and Minerals

2.1 Biominerals

Biominerals are minerals which are formed in an organism under the control of genes; these genes encode matrix components or proteins needed for enzymatic activity, trafficking, or other cellular activities. They often differ from the thermodynamically most stable form that is found in the non-biological environment. The formation of biominerals needs catalysis by the living organism. Often it is not possible to prepare them in vitro.

About 40 different biominerals are known [1]. Most frequent are calcite, aragonite, and vaterite composed of calcium carbonate, Ca_2CO_3, and hydroxyapatite [formula $Ca_{10}(PO_4)_6(OH)_2$] composed of calcium phosphate, $Ca_5(PO_4)_3OH$. Opal, the amorphous glass state of siliciumdioxide, $SiO_2(H_2O)_n$, is also very frequent. Magnetite, a mineral with the chemical composition $Fe^{2+}Fe_2{}^{3+}0_4$ has attracted much interest because of its magnetic properties. Note that minerals are known that have identical chemical composition yet with different symmetry properties. The structural properties of these minerals including the distance between their constituent ions will be quite different. For example, the distance between Ca^{2+} atoms in calcite differs from those in aragonite, a fact which is important for the potential interaction with regulatory proteins.

Most biominerals are found in a microcrystalline state. The microcrystals have an elongated shape or a plate-like structure. Typical dimensions are 10–100 nm. Depending on the mineralized system, the microcrystals are arranged in a large variety of structural assemblies. Some minerals are found in an amorphous state, such as is opal of silica, which is formed in a solid amorphous state, often called the glass-like state.

J. Engel, *A Critical Survey of Biomineralization*,
SpringerBriefs in Applied Sciences and Technology,
DOI 10.1007/978-3-319-47711-4_2

2.2 How to Detect Biomineralization?

Detection of biomineralization is often very straightforward. For example the hardness of mollusk shells, corals, and enamel and their resistance against combustion suggests an inorganic nature. In these cases, sufficient material is available for chemical analysis, X-ray crystallography, and other methods. Although the mineralized material may look rather uniform at a first glance, investigation by high resolution methods such as electron microscopy will reveal patterns of microcrystals.

In many cases, characterization of biominerals is more difficult. For small objects like magnetite crystals in bacteria, the Mg Calcite containing chewing elements of sea urchin or the stinging needles of nettles, a high contrast in electron microscopy images may provide the first hint of the presence of a mineral. A technical problem may arise with thin sections. Tissues are normally demineralized before sectioning in order to save the quality of the precious knives. Electron dispersive X-ray spectrometer (EDS) attachments are frequently combined with scanning and transmission electron microscopes. With them an elemental analysis is possible, yet the full identification of the mineral remains open. In some cases, removal of the organic parts of the organism may be of help. A classical example is the diatoms. Their highly sophisticated skeletons made of amorphous opal are best visible by light and electron microscopy of diatomaceous earth, also called Kieselguhr. This materia is composed of fossils of the algae in an organic-matter-free state.

Reference

1. Mann S (2001) Biomineralization, principles and concepts in bioinorganic materials chemistry. Oxford University Press

Springer

http://www.springer.com/978-3-319-47710-7

A Critical Survey of Biomineralization
Control, Mechanisms, Functions and Material Properties
Engel, J.
2017, VIII, 64 p. 27 illus., 17 illus. in color., Softcover
ISBN: 978-3-319-47710-7