Self-assembled nanostructures in biomineralization

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Organic molecules can control crystal shape, size, texture, and even crystal structure during biomineralization. Carbonates (calcite and aragonite) in shells and apatite in bones are good natural examples. The controlled growth of minerals in organic-bearing media in laboratory will help us to understand natural processes of biomineralization. The results can also help us to develop nano-devices using controlled biomimic crystal growth. In this paper, we will focus on minerals formed through self-assembling of inorganic components (silica, Ca-carbonate) and surfactants and surfactant-like organic components that are released from bacteria (such as, fatty acids). Lipids, including fatty acids, are components of bacterial cell membrane. When bacteria die, the lipids are released. Fatty acids and lipids derived from bacteria, are common organic compounds in soils. By carefully comparing the minerals prepared in the presence and absence of the organic compounds with the natural mineral samples, we will be able to understand how the organics affect the mineral formation.

We use a co-polymer (P123) and a positively charged surfactant CTAB with hydrophilic heads and hydrophobic tails (as chemical analogs for lipids) to synthesize amorphous silica and calcite from the solutions containing the organics. Our results show synthesized nanoporous (nano-channel-like) silica having a rod-like morphology precipitated from silicate solution, and onion-like silica spheres precipitated from Al-bearing silicate solution. Diatom-like silica frameworks with nano-porous structures are also synthesized. Nanoporous and nano-crystalline calcite occurs in natural dust deposit. Synthesized calcite crystals precipitated from solution containing surfactant CTAB also show self assembled nano-porous structure. SEM image shows cube-like shape of the calcite. TEM image and electron diffraction pattern show the cube-like calcite is composed of nano-bricks of calcite crystals. It can be inferred that unusual shaped minerals with self-assembled nano-structures can be used as signatures for bacterial activities. Such kinds of minerals do not have to be replacement products of bacteria, i.e., micro bacterial or nano-bacteria fossils. We expect naturally derived biological organic compound (such as lipids) may also template mineral precipitation, which will also leave finger prints of the nano-structures in minerals. Hexagonal wurtzite ZnS can crystallize from solutions containing amine-bearing organics, although cubic spharelite phase is a stable structure at low temperature. These results may shed new light on controlled growth of aragonite and calcite in shells. This research is supported by NSF (EAR02-10820) and LDRD program of DOE.

Sm-Nd, $^{40}Ar/^{39}Ar$ and fission track ages of granulites from lower crust: Implications for exhumation history of the Panxi Micro Oldmass in SW China

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Panxi Micro Oldmass is the oldest terrane in the western margin of the Yangtze Block. Some intermediate-basic granulites are considered crystalline basement of lower crust in the terrane. Granulite-facies metamorphism of the granulites was developed in the periods from 1186Ma to 1128Ma. The origin of granulites was related with the collision orogenic process between micro paleolands when assembly of the Rodinia Supercontinent. Amphibolite-facies retrogressive metamorphism of the granulites was taken place in the periods from 877Ma to 825Ma. The periods were consistent with the breakup time of the Rodinia Supercontinent. $^{40}Ar/^{39}Ar$ ages and fission track (FT) ages of granulites in the Panxi Micro Oldmass show that the vertical movement history of crustal rocks was a slower uplift process of the rigid terrane in the time from the Neoproterozoic to Mesozoic. Cooling rates of crust were 1.8, 0.7 and 0.4°/Ma, respectively. Subduction from the India Plate northward Euroasia Plate makes rapid exhumation of the Qinghai-Tibet Plateau in Cenozoic; and the latter block puts the squeeze on the Panxi Micro Oldmass to rapidly uplift in the same time. The cooling rates were from initial 0.9-2.0 °/Ma to recent 4.1-7.8 °/Ma. The collision orogeny between two blocks results in exhuming granulite-facies crystalline basement to outcrop on the surface.

This work was supported from the National Natural Science Foundation of China (Grant No. 49972062).