

Molecular fossils and early life

JOCHEN BROCKS¹ AND JILLIAN BANFIELD²

¹Research School of Earth Sciences, The Australian National University (jochen.brocks@anu.edu.au)

²Department of Earth and Planetary Sciences, UC Berkeley

Life in the Precambrian was dominated by bacteria and archaea, organisms that rarely leave diagnostic cellular remains in the fossil record. However, hydrocarbon biomarkers, the molecular fossils of natural products such as lipids and pigments, can yield a wealth of information about Precambrian ecosystems. Biomarkers often retain the diagnostic carbon skeleton of their biological precursors and may survive in sedimentary rocks for hundreds of millions of years. Many biomarkers are diagnostic for specific microbial groups such as methanogens, methanotrophs or phototrophic bacteria and, thus, may give information about ancient biodiversity. For instance, biomarkers discovered in mudstones that were deposited in a seaway in northern Australia 1,640 Ma ago describe a marine habitat that was fundamentally different from ecosystems observed later in Earth history. In this ancient sulfidic marine basin, eukaryotic algae were either insignificant or absent, and primary production was dominated by phototrophic green and purple sulfur bacteria. Generally, biomarkers could answer outstanding questions about Precambrian ecology and evolution, such as how ecosystems responded to the oxygenation of the atmosphere ~2.4 billion years ago or how life responded to massive glaciations in the Neoproterozoic.

However, there is a major obstacle that hampers the application of biomarkers as palaeoenvironmental proxies: the incomplete knowledge of the lipid biosynthetic capacity of living organisms. According to some estimates, less than 1% of microorganisms can be isolated from the environment and grown in pure culture, and the biomarker content of these uncultivated microbes remains almost always unknown. Detecting and describing the lipids and pigments produced by those 99% of microorganisms that can not yet be cultured would boost the value of biomarkers extracted from ancient rocks.

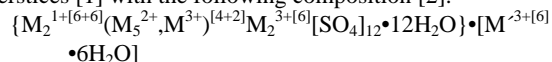
This great challenge might be solved in the coming decade by combining lipid research with environmental genomics and microbial community proteomics. Of particular interest will be studies of communities where it is possible to reconstruct nearly complete genomes, proteomes and lipid profiles of dominant microorganisms taken directly from modern environments without cultivation. These genomes will be screened for genes involved in lipid and pigment biosynthesis and matched with corresponding enzymes and lipids detected in the same sample. In addition to defining the diversity of as yet unknown branches of the tree of life, this will contribute to new understanding of the phylogenetic distribution of potential biomarkers produced by microorganisms, even if they evade isolation. The intricate knowledge of the lipid biosynthetic machinery of present ecosystems will then serve to elucidate new biomarkers and biomarker patterns in ancient sedimentary rocks.

Synthesis, crystal structure and application of compounds with Copiapite- and Voltaite structure

B. BROEMME AND H. POELLMANN

Martin-Luther-University Halle-Wittenberg,
Mineralogy/Geochemistry, von-Seckendorff-Platz 3,
Germany (beatrix.broemme@geo.uni-halle.de)

Voltaite is a three-dimensional polymerization of complex octahedral-tetrahedral chains with K in located in the interstices [1] with the following composition [2]:



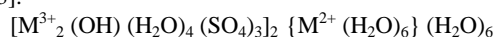
M¹⁺: K, Rb, NH₄, Tl, Li

M²⁺: Mg, Mn, Fe, Co, Zn, Cd

M³⁺: Fe

M⁻³⁺: Al, Fe

In the copiapite-group minerals, corner-sharing [M₂(TO₄)₂Ø₇] clusters link through additional tetrahedra to form [M₂(TO₄)₃Ø₅] chains along [101], which are linked together by hydrogen bonds involving unconnected {Fe²⁺(H₂O)} octahedra and interstitial water groups [1]. The general chemical formula of the copiapite group minerals is [3]:



M²⁺: Na⁺, K⁺, Cu, Fe²⁺, Mn, Mg, Zn, Al, Fe³⁺

M³⁺: Fe³⁺, Al³⁺

Synthesis and Results

Voltaite minerals can be synthesized by reaction of metalsulfates and sulphuric acid in an aqueous solution. The crystallisation process takes place at a temperature of 80°C.

Copiapite can be synthesized by the method developed by MAJZLAN [4] and SCHARIZER [5].

The phase identification and characterisation is done by X-ray diffraction, thermogravimetry, scanning electron microscopy and IR-spectroscopy.

Conclusions

The improvement of the synthesis and the investigation of the capacity of reaction under changing conditions of solubility and stability is the intent of the investigation.

The high ability of the exchange of cations indicates a possible use in agriculture, as a water binder or as a short time storage mineral, which will be investigated.

References

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