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Occurrences of ikaite and pseudomorphs after ikaite in Patagonian lakes – crystal morphologies and stable isotope composition

Markus Oehlerich (1), Christoph Mayr (1,2,3), Erika Griesshaber (1,2), Christian Ohlendorf (4), Bernd Zolitschka (4), Nuria Sánchez-Pastor (1), Barbara Kremer (5), Andreas Lücke (6), Oliver Oeckler (7), Wolfgang Schmahl (1,2)

(1) LMU-München, Paleontology, Earth and Environmental Sciences, München, Germany (m.oehlerich@lrz.uni-muenchen.de), (2) Geo-Bio-Center, LMU, Germany, (3) present address: Institute of Geography, University of Erlangen-Nuremberg, Germany, (4) GEOPOLAR, Institute of Geography, University of Bremen, Germany, (5) Institute of Paleobiology, Biogeology Department, Polish Academy of Sciences, Poland, (6) Institute of Chemistry and Dynamics of the Geosphere 4: Agrosphere (ICG 4), Forschungszentrum Jülich, Jülich, Germany, (7) Department of Chemistry, LMU, Munich, Germany

Ikaite ($CaCO_3 \bullet 6H_2O$), a hydrated calcium carbonate mineral occasionally found in marine sediments, has so far rarely been reported from non-marine sites. Modern ikaite and calcitic pseudomorphs after ikaite were recently discovered in Patagonian Argentina at the polymictic lakes of Laguna Potrok Aike (51°57´S, 70°23´W) and Laguna Cháltel (49°57´S, 71°07´W), respectively. Both lakes are of volcanic origin and have phosphorous-rich, alkaline waters, but differ in altitude (790 m asl and 110 m asl for Laguna Cháltel and Laguna Potrok Aike, respectively) and water temperature.

The aim of this study is (1) to investigate conditions for the formation of ikaite and its transformation to more stable, water-free carbonate pseudomorphs after ikaite and (2) to assess the potential of ikaite and calcite pseudomorphs after ikaite as a paleoenvironmental tool in freshwater lakes. Crystallographic, morphological and isotopic characteristics of the pseudomorphs were investigated.

Ikaite crystals were found (in September 2008) primarily on aquatic macrophytes and cyanobacteria colonies at Laguna Potrok Aike. Ikaite crystals transformed quickly to calcite pseudomorphs after ikaite after recovery from the cool lake water (4°C). The crystal structure of ikaite was investigated with single crystal X-ray diffraction on samples that were permanently kept cold (in the lake water). At Laguna Cháltel calcite pseudomorphs after ikaite were discovered in littoral sediment cores from 25 m water depth.

The mm-sized, porous, polycrystalline calcium carbonate aggregates from the 104 cm long sediment core of Laguna Cháltel are morphologically pseudomorphs after ikaite. SEM and XRD analyses highlight that these pseudomorphs consist of several μm-small calcite crystals in a calcitic matrix. The shape of these micro-crystals changes from rounded to fibrous with increasing sediment depth. Some specimens show casts of cyanobacteria trichomes.

The oxygen isotopic composition of calcite pseudomorphs after ikaite from both lakes was analyzed. Calculating water temperatures during the ikaite precipitation assuming isotopic equilibrium for calcite and including modern water isotope ranges do not result in realistic estimates. Thus, either the calcite isotope fractionation factors are not applicable to these pseudomorphs, because e.g. the transformation to calcite pseudomorphs after ikaite caused isotope exchange or the carbonate precipitation occurred in disequilibrium. Nevertheless, the offset between oxygen isotope values of the sedimentary calcitic pseudomorphs from Laguna Cháltel and the modern ones from Laguna Potrok Aike corresponds to the differences present in lake water isotopic composition. Thus, calcite pseudomorphs after ikaite may serve as a proxy for paleo-lake water isotope variations.

The crystallisation of ikaite in these lacustrine environments is presently simulated by different methods: (1) Evaporation from the lake water and (2) with modified diffusion silica gel experiments using the lake water and synthetic solutions.