EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office via the User Portal:
https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do

Deadlines for submission of Experimental Reports

Experimental reports must be submitted within the period of 3 months after the end of the experiment.

Experiment Report supporting a new proposal ("relevant report")

If you are submitting a proposal for a new project, or to continue a project for which you have previously been allocated beam time, you must submit a report on each of your previous measurement(s):

- even on those carried out close to the proposal submission deadline (it can be a *"preliminary report"),*
- even for experiments whose scientific area is different form the scientific area of the new proposal,
- carried out on CRG beamlines.

You must then register the report(s) as "relevant report(s)" in the new application form for beam time.

Deadlines for submitting a report supporting a new proposal

- 1st March Proposal Round - **5th March**
- 10th September Proposal Round - **13th September**

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report in English.
- include the experiment number to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Investigating the structure and coherent nanoprecipitates in biogenic high-magnesium calcite	**Experiment number**: MA-4534
Beamline: ID-22	**Date of experiment**: from: 24/10/2021 to: 31/10/2021	**Date of report**: 24/07/2022
Shifts: 12	**Local contact(s)**: Giorgia Confalonieri	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Boaz Pokroy* – Department of Materials Science and Engineering, Technion – Israel Institute of Technology.

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Giuseppe Falini – Laboratory University of Bologna Department of Chemistry "Giacomo Ciamician".

Report:

Published work:

Bianco-Stein, N., Polishchuk, I., Lang, A., Portal, L., Dejoie, C., Katsman, A., & Pokroy, B. (2022). High-Mg calcite nanoparticles within a low-Mg calcite matrix: A widespread phenomenon in biomineralization. *Proceedings of the National Academy of Sciences*, *119*(16). https://doi.org/10.1073/pnas.2120177119

Abstract: During the process of biomineralization, organisms utilize various biostrategies to enhance the mechanical durability of their skeletons. In this work, we establish that the presence of high-Mg nanoparticles embedded within lower Mg-calcite matrices is a widespread strategy utilized by various organisms from different kingdoms and phyla to improve the mechanical properties of their high-Mg calcite skeletons. We show that such phase separation and the formation of high-Mg nanoparticles are most probably achieved through spinodal decomposition of an amorphous Mg-calcite precursor. Such decomposition is independent of the biological characteristics of the studied organisms belonging to different phyla and even kingdoms, but rather originates from their similar chemical composition and a specific Mg content within their skeletons, which generally ranges from 14 to 48 mol% of Mg. We show evidence of high-Mg calcite nanoparticles in the cases of 6 biologically different organisms all demonstrating more than 14 mol% Mg-calcite and consider it likely that this phenomenon is immeasurably more prevalent in nature. We also establish the absence of these high-Mg nanoparticles in organisms whose Mg content is lower than 14 mol%, providing further evidence that whether or not spinodal decomposition of an amorphous Mg-calcite precursor takes place is determined by the amount of Mg it contains. The valuable knowledge gained from this biostrategy significantly impacts the understanding of how biominerals, though comprised of intrinsically brittle materials, can effectively resist fracture. Moreover, our theoretical

calculations clearly suggest that formation of Mg-rich nanoprecipitates greatly enhances the hardness of the biomineralized tissue as well.