Biorestoration Potential of Carbonatogenic Bacteria on Lithotypes: SEM and AFM characterization

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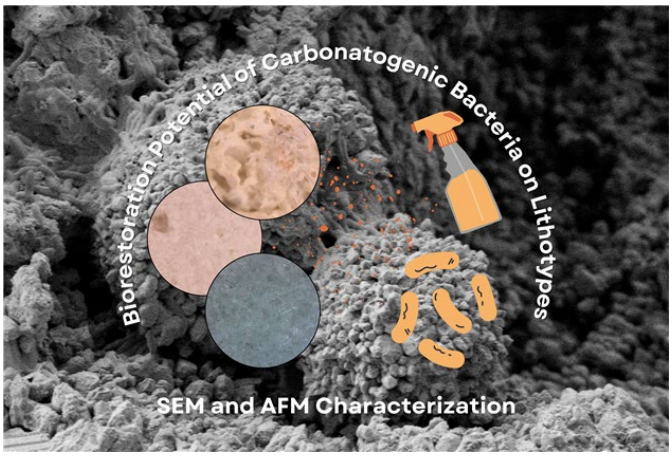
Background incl. aims.
Microbially-induced calcium carbonate precipitation (MICCP), a bio-geochemical process, is a promising technology for eco-friendly applications particularly in the restoration of ornamental limestones.
This study explores the efficacy of the biorestoration treatment using Lysinbacillus fusiformis 3.20 strain as a carrier for the MICCP on three different lithotypes: calcarenite (MC), travertine (TR), and marble (MA). Despite sharing similar mineral compositions, these lithologies originate from different depositional settings, resulting in different petrophysical properties and microstructural features. To understand the biomineralization of the three different lithotypes the surface alterations and nanostructural changes were characterized by SEM (Scanning Electron Microscopy) and AFM (Atomic Force Microscopy).

Methods.
Small bricks of the three lithologies were treated spraying the bacterium culture twice a day for seven days at 28°C. Nanocaracterization of the surfaces of the three lithotypes was performed pre- and post-treatment using the Zeiss Auriga (SEM) operating at 1.5 keV and Bruker's Dimension Icon (AFM) using RTESPA-300 probes in tapping mode.

Results.
SEM micrographs revealed significant differences between the untreated and treated samples, particularly on the surfaces of the MC and TR stones. The treated samples showed the presence of calcified bacterial cells and newly formed crystals. In the MC samples, the crystals presented rhombohedral shapes, while the TR samples showed less homogenous aggregates. However, the treatment showed no significant effect on the MA samples, as no visible crystals or bacterial cells were observed after treatment. AFM analysis confirmed these results, showing the presence of bacteria and new crystals on the MC and TR samples post-treatment, with the bacterium being able to deposit calcium carbonate on the pore edges and covering the surfaces.

Conclusion.
The results obtained in controlled laboratory conditions emphasize that for the same treatment, the morphological variations of the bioprecipitation changes are strongly dependent on the lithology. Thus, for a future in situ application of this technique for stone conservation and restoration, the treatment will be optimized depending taking into account the differences of the lithologies.

Graphic:



Keywords:

Biorestoration, SEM, AFM, biomineralization

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