



Bioconservation of the marble base of the Pietà Rondanini by Michelangelo Buonarroti

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Microorganisms have often been associated with detrimental effects on the integrity of cultural heritage made of stone. However, there has been growing evidence that they could be used to remediate the deterioration processes on historical objects of art, a process named bioconservation. Bioconservation of surfaces have some advantages over traditional cleaning methods. Chemicals are not always selective and mechanical treatments can sometimes damage the surface. In contrast, this biotechnological method is non-destructive and represents an environmental-friendly alternative as microorganisms act in the same way as they do in their natural habitats.

First of all, microorganisms with the ability to remove undesired materials are selected. If they are not acquired from microbial collections but they are isolated from environmental habitats they must prove to be non-pathogenic species.

In this work the ability of selected microorganisms to remove sulphate, in the form of gypsum, was proved. The biological treatment was carried out on the marble base of the Pietà Rondanini by Michelangelo. This base was altered by grey-black deposits, firmly adhering on the marble surface, chemically characterised as calcite and gypsum (ratio 2:1). The proper biological treatment would have involved both sulphate-reducing bacteria and calcite-solubilising bacteria. However, the latter were not considered as the sound marble is made of calcite. As a consequence, it was decided to use the sulphate-reducing bacterium *Desulfovibrio vulgaris* sub. *vulgaris* (ATCC 29579) that had showed a good yield of H₂S, a gas that is liberated in the air. The medium

used was the 63 DSMZ *Desulfovibrio* partially modified (no iron was present in the medium). Iron is not welcome as together with reduced sulphur compounds produces FeS that forms black crystals precipitates. In addition, prior to use the liquid broth was filtered to remove traces of black crystals. After this step, cells were centrifuged and resuspended in a phosphate buffer at pH 7 containing sodium lactate. Carbogel powder was then added to the suspension to produce a delivery system with immobilised cells. The activated gel was applied to the altered surface. After 24-30 hours the gel was removed and the bacteria were continuously monitored after the treatment to prove their complete removal. Once the bacteria were removed, grey-black deposits were not anymore present and also the undesired calcite was easily taken out.

Finally, the air in the room, where the Pietà Rondanini is stored, was monitored to evaluate the potential risks of microorganisms and fungal spores in the sculpture environment.