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Carbonatogenesis at the Crag: Can bacteria repair rock scarring?

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Abstract

Rock scarring is the permanent damage of rock faces caused in association with climbing. Carbonatogenic bacteria could be the key to repairing this previously irreparable damage. Using methods developed for the preservation of architectural, structural, and decorative limestone, crags could be repaired. Highly specific biological mortars can be designed and applied to areas of limestone crags where scarring has occurred. Further research is required to isolate carbonatogenic bacteria from crags and tests are needed to understand if these methods are viable and structurally safe for future climbers under the environmental conditions of a crag.

Keywords: *Environment; Earth Sciences; Microbiogeology; Traditional Climbing; Climbing Hardware; Rock Scarring*

Whether it be due to old pitons (figure 1), polishing from overuse or intentional damage by antisocial climbers, rock scarring has always been an unfortunate reality of rock climbing. Whilst many bodies such as the British Mountaineering Council and much of the climbing populous preach prevention of scarring, very little has been done to repair the damage. In this paper I discuss and explore the possible applications of carbonatogenic bacteria as a potential solution to reverse the damage to limestone crags (steep, rugged rock faces) and preserve them for generations of climbers to come.

Figure 1 – Pitons are designed to be hammered into cracks to provide protection to climbers, because of this they are intended to be very hard to remove. Removal of pitons causes rock scarring as the surrounding rock must be removed as well. Left: Pin scarring in Yosemite national park (granite) [1]. Right: Piton being hammered into a crack [2].

The study of limestone deterioration primarily focuses on structural and decorative limestone. Current preventative and curative treatments include the use of synthetic resins that polymerise inside the stone pores [3]. Chemical-based treatments face problems for these applications such as lack of longevity and environmental damage, as such new methods are required. These problems are exacerbated in the crag environment so currently there is no restorative technique for crags. Considering this we look to nature for a solution, many carbonate rocks are already cemented by calcium carbonate precipitation induced by microbes [4]. Administration of bacterial colonies to areas of rock scarring could have targeted and accelerated results of a process that is already happening elsewhere on the same crag.

The protection of structural and decorative limestone is widely considered to have two main purposes: protection from environmental weathering and repair of structural damages such as pores and cracks. When discussing rock scarring, the latter point is of more interest. In this application I adopt a similar approach to that taken by Le Métayer-Levrel et al. [3] using biological mortars in the preservation of ornamental limestone would be highly effective.

Biological Mortars

The premise of biological mortars, as outlined by paper [3] and addressed in the patent FR2734261 [5], sees a mineral filler mixed with suitable amounts of carbonatogenic (carbonate producing) bacteria such that the bacteria bind the powdered filler into solid rock. The mortar is treated regularly with a liquid nutrient media to improve bacterial growth and in turn ensure structurally stronger rock (see figure 2).

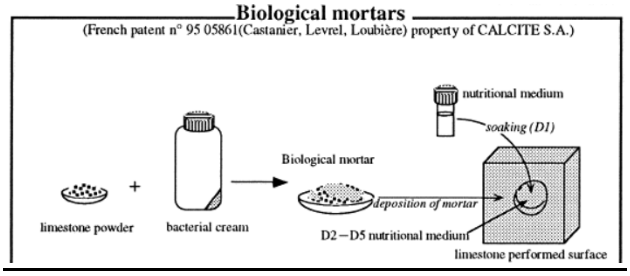

Figure 2 – Simplified illustration of the application of biological mortar [3].

When repairing architectural and decorative limestone, the priority is efficacy and cost. For this, bacterial communities are taken from natural carbonate-producing environments and isolated in the laboratory. The aim of the laboratory study is to identify the carbonatogenic strains and their carbonatogenic yield, the higher yield indicating faster carbonate precipitation. The next stage of study is to identify the ideal culture media for the highest yield bacteria. It should be noted that due to the scale of application on structural and decorative limestone, financial constrains require the use of sub-optimal growth media compared to those used in the laboratory. Likewise, feeding cycles were restricted to five applications. It was observed that feeding schedule affects the structure of the formed limestone, a 24-hour cycle producing fine-grained biocalcin whilst a 48-hour feeding cycle produced larger-grained biocalcin [3]. The so called Biocalcin is the term given to the surficial protective coating comprised of the carbonate encrusted bodies of the bacteria as well as carbonate excretions, as observed in natural rock formations. The excreted material fills pores in the surrounding rock, rooting the applied mortar to the existing rock replicating the structure of the undamaged rock.

When applied to the SE tower of Saint Médard Church, the authors found the biomineralization facilitated by carbonatogenic bacteria protected the limestone even when the biocalcin was exposed to varying weather conditions.

Crag-based Biological Mortars

Considering the approach taken by in the paper [3], I propose a similar method to be used at crags to repair rock scarring using native limestone samples and bacteria that has be isolated from the local crag environment.

Whilst prior studies have strived for the most efficient carbonatogenic bacteria, as there are few ecological risks associated with the introduction of a new bacteria, more care must be taken at the crag. The use of native carbonatogenic bacteria species gathered from the crag are ideal as growth is known to be possible under crag conditions. Likewise, limestone can be gathered from the local area of the crag to ensure the most natural, site specific, integration of the biological mortar.

As prior research suggests, feeding frequency can impact the size of the newly formed carbonate excretions. The structure of the limestone at the target crag should be studied to produce an optimal feeding schedule, unique to the crag. This may be achieved via scanning electron microscopy. During these studies, ideal growth media must be found to provide the native bacteria the most optimal conditions upon seeding for consolidation of colonies and ultimately biocalcin formation. Previous applications [3] have faced the issue of financial restraints with regards to feeding and materials however when applied to crags, the scale is far smaller (see figure 1, left) and thus less materials are required allowing for more feeding cycles and more optimal processes.

A problem faced by biological mortar application at climbing crags is the temperamental environmental conditions. Unlike the applications laid out previously [3], the crag is far harder to protect and the remote nature results in far more inclement weather than that seen in past studies. This is where the use of native species should be beneficial as we know they can grow under the normal conditions at a crag.

Conclusion

Biological mortars appear to be a promising solution to rock scarring at climbing crags. Further studies to isolate carbonatogenic bacteria native to the crags is required, however the evidence presented by paper [3] suggests that a biological mortar can repair limestone. Further research is necessary as thus far we lack information on the viability of native crag bacteria in biological mortars under the environmental conditions of the crag, and optimisations for feeding the system. The long-term strength of the repaired rock must also be studied to assess safety of the rock for removable climbing protection in the event of repeated climbs. A problem unique to this application.

References

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